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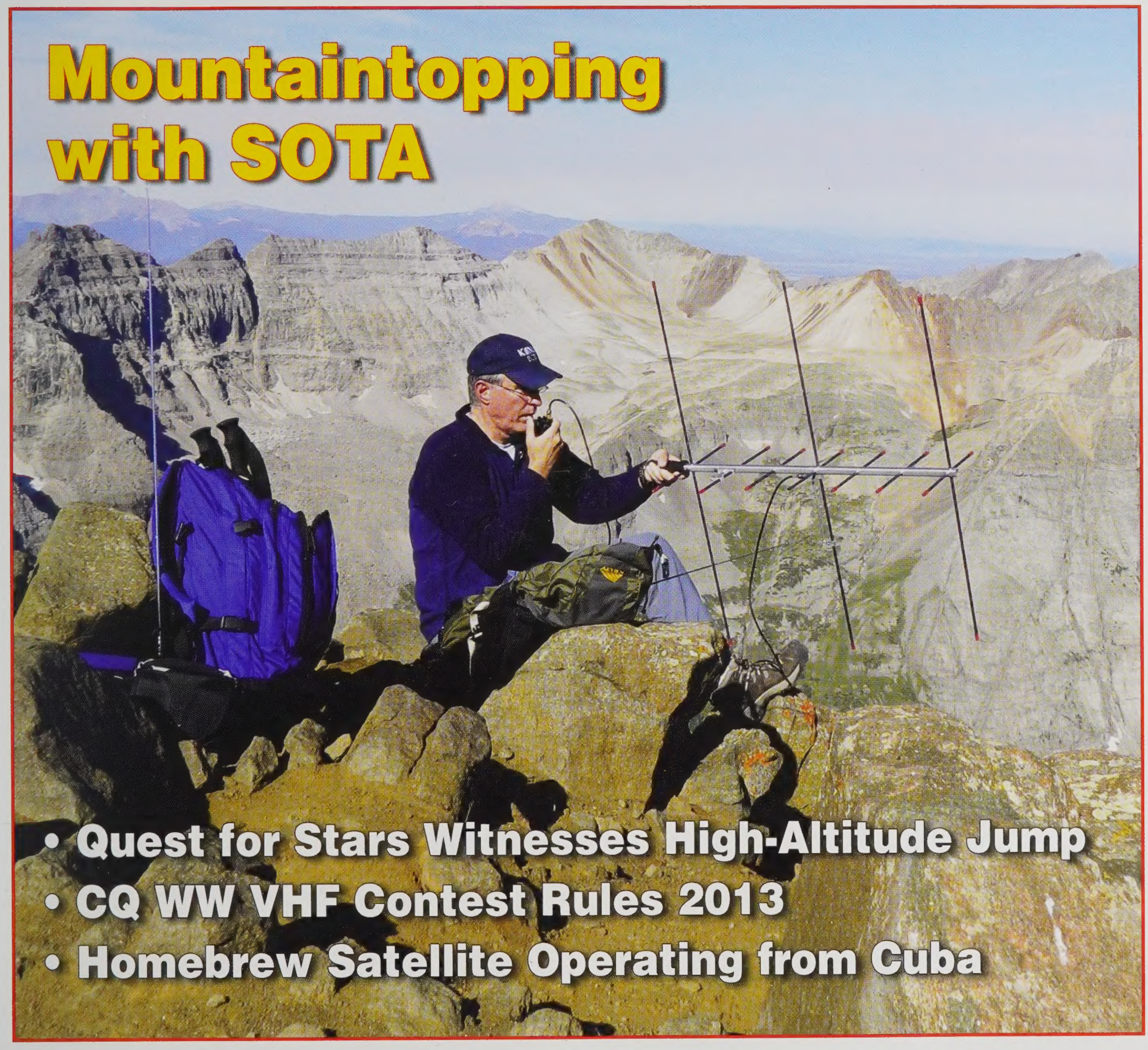

Mountaintopping with SOTA

- Quest for Stars Witnesses High-Altitude Jump
- CQ WW VHF Contest Rules 2013
- Homebrew Satellite Operating from Cuba

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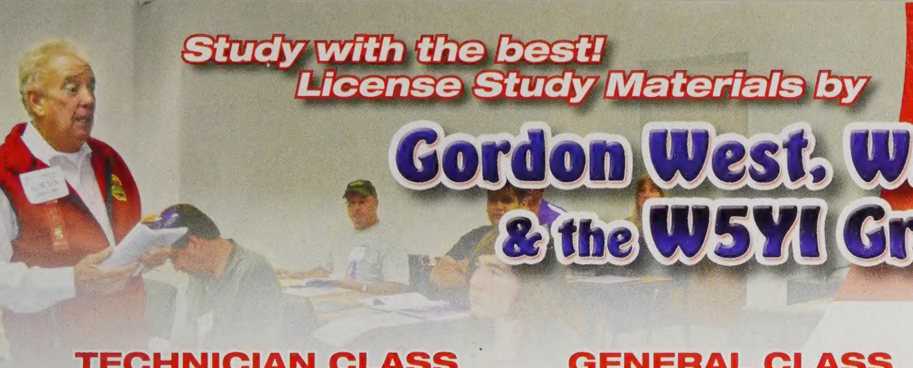

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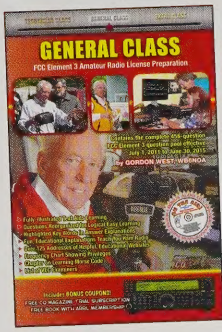

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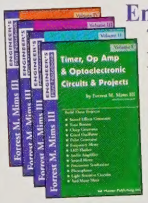

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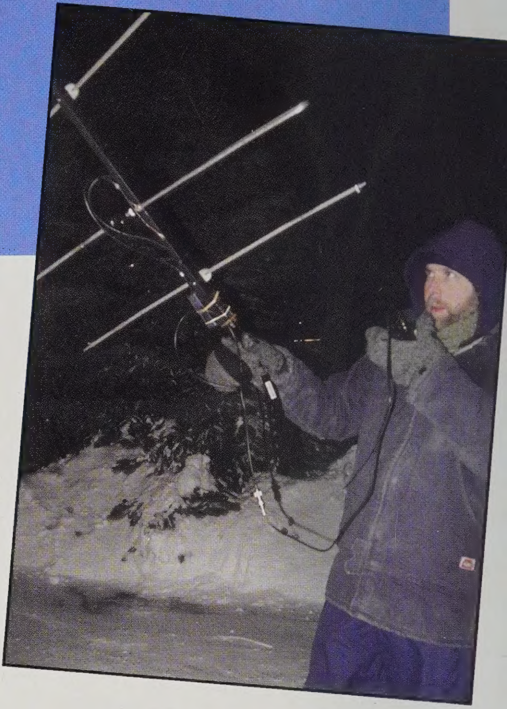

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On The Cover: The cover shot features "FM" column editor Bob Witte, K0NR, operating from the summit of Mt. Sneffels, which is located in the Uncompahgre National Forest, Colorado. The cover photo was taken by Joyce Witte, K0JJW, during their Summits On The Air activation on August 5, 2012. For details see page 50.

CQ VHF Ham Radio
Above 50 MHz

LINE OF SIGHT

A Message from the Editor

SOTA, Hilltopper, and CQ WW VHF Contest

This time the cover shot features FM column editor Bob Witte, K0NR, operating from the summit of Mt. Sneffels, which is located in the Uncompahgre National Forest, Colorado. According to the University of Montana's Wilderness.net website about the mountain (http://www.wilderness.net/index.cfm?fuse=NWPS&sec=wildView&WID=384):

> Members of the Hayden Survey purportedly named the peak after the Icelandic mountain in Jules Verne's book *Journey to the Center of the Earth*. "Sneffels" is the Nordic word for snowfield.

The cover photo was taken by Joyce Witte, K0JJW, during their Summits On The Air (SOTA <see: http://www.sota.org.uk>) activation on August 5, 2012.

I bring attention to the Witte's activation to segue to writing about SOTA, hilltopping, and the CQ WW VHF Contest. As you can read in Bob's column, SOTA is in its 11th year of existence. While much of the activity is HF oriented, there is a growing interest in VHF-and-above activations, such as the participation by Bob and Joyce last August.

During their outing, they made a total of 14 unique contacts between them, with Joyce making one and doing most of the logging for Bob for the other 13 QSOs. True to its name, Sneffels, the mountain began to be a snowfield for the Wittes as they made their way down from its peak. More details of their activation and SOTA can be found in Bob's "FM" column, which begins on page 50. Additional details can be found on his blog website: <http://www.k0nr.com/wordpress/2012/08/a-great-day-of-mountaintop-radio/>.

Bob mentions that the SOTA program "has really taken off in North America." In consideration of this increased enthusiasm for the program, this July might be a great time for activating several summits around the country during the CQ WW VHF Contest (July 20–21; see the rules on page 70). The Hilltopper category states that it is a single-op QRP portable category that is open to all bands for a maximum of six hours activation. While the contest regulations state that any power source is acceptable, it is unlikely that you will find a convenient receptacle to plug in your 30-amp switching power supply. Therefore, battery or solar cells will be the most likely source of power.

In the coming months there are several other contests scheduled . See the "Beginner's "column by James Duffey, KK6MC, which begins on page 74, for a review of some of them. Also, check the Current Contests listing within the Quarterly Calendar, which begins on page 6.

If you do decide to activate a summit, then in order to qualify for all of the awards offered by SOTA, you must list your activation on SOTAwatch, which is found at <http://www.sotawatch.org> (see figure 1 in Witte's "FM" column). By doing so, you will alert the world to your forthcoming activity. Be sure to familiarize yourself with how activations are listed. The Wittes are listed as W0/UR-001, which is the highest summit (of 56) in the Uncompahgre National Forest.

Regarding activation, I am interested in articles that are similar to the approach that Bob took with his column. I would like to see articles that both report on activations and also construction techniques that you use to make your operation possible. One starting point for construction ideas is Kent Britain, WA5VJB's "Antennas" column, which begins on page 67. In it, he describes three versions of the same antenna that are designed for 144-, 223-, and 432-MHz, respectively. If you develop a story from your experiences, please let me know.

An Airborne Front Row Spot to Witness History

The student-centered, STEM (science, technology, engineering, and math) focused Quest for Stars (http://questforstars.com) has had an incredibly wonderful string of successful ventures. Last October they added to that list by launching a balloon with a payload to track the ascent of Felix Baumgartner's STRATOS capsule as it moved upward to the spot where he would alight on his record-setting jump.

Perhaps the most remarkable aspect of the adventure was that the payload from the Quest for Stars' balloon landed across the street from the location of Baumgartner's recovery team. Bobby Russell, KJ6NKA, tells the rest of this remarkable story beginning on page 8.

More recently, Quest for Stars was honored as the winner of a 2013 Telly Award for video production of their video: "New Horizons: The Road to Discovery, which can be seen at: <https://www.youtube.com/watch?v=2NdZdZzMMf8>. Quest for Stars also submitted a video honoring the late Christa McAuliffe, the astronaut-teacher who died aboard the Space Shuttle Challenger when it blew up shortly after launch on January 28, 1986. That video, entitled "Christa: Where the Heart is (Tribute to America's Teacher in Space)," which will bring a tear or two to your eyes, can be seen at: <https://www.youtube.com/watch?v=3zrNNwZuavo>.

The latest project is the launch of a UAV (Unmanned Arial Vehicle) from a balloon and to recover it on board a moving boat off the coast of San Diego. The project name is StratoShuttle. More information on the project can be found at : <http://questforstars.com/?page_id=1383>. The launch window is between early April and May 25, 2013. Perhaps you will read that story in a future issue of *CQ VHF* magazine.

Homebrew Satellite Operation from Cuba

I became acquainted with Hector Martinez, CO6CBF, by way of AMSAT's 2012 Symposium *Proceedings*. It contains the basis for his article which begins on page 18.

I contacted Hector for reprint permission, which he gladly granted to us. The more I read his piece and about him, the more fascinated I became with his ingenuity and drive. You can read about his history in this article. However, it is hard to keep up with his current activity. You can read about in the sidebar about his FO-29 contact with Joe Murphy, EI5EV, in IO62 in Ireland. However, within days of having that sidebar placed for printing, Hector extended his range to 7330 km, which is near maximum for that satellite via a contact with David, EA4SG, in IN80cp. Hector operated from the top of a tall building so as to improve his horizon visibility toward Europe. Commenting on his QSO, Hector stated that he had "just an 88-second window." You can read more about that QSO at: <http://www.southgatearc.org/news/ april2013/7330_km_contact_on_fo29.htm?utm_source=feedburner&utm_medium=email&utm_campaign=Feed%3A+AmateurRadioNews+%28Southgate+Amateur+Radio+News%29&utm_content=Yahoo!+Mail#.UWP5NVc9Zk->.

And Finally . . .

I am looking for articles that use open-source hardware for projects. Recently, I read about the Raspberry Pi being used as a WSPR beacon on HF (see: <tinyurl.com/raspberry-pi-transmitter>). Perhaps that 10-mw output can be put to use as a WSPR beacon on 144 MHz. If you design such a project, please send it to me. Also, thank you all for your ongoing support for this, your magazine for the VHF-and-above amateur radio frequencies.

Until next time . . . 73 de Joe, N6CL

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QUARTERLY CALENDAR OF EVENTS

Current Contests

The **European Worldwide EME Contest 2012**: Sponsored by DUBUS and REF, the EU WW EME contest is intended to encourage worldwide activity on moonbounce. Information for this contest is available at : <http://www.marsport.org.uk/dubus/eme. htm>.

Spring Sprints: These short-duration (usually four hours) VHF+ contests are held on various dates (for each band) during the months of April and May. For specific dates, see the Southeast VHF Society website at: <http://www.svhfs.org>.

The **Six Meters Marathon**: OH3AG invites you to participate in the Seventh Global Six Meters Marathon. The objective of the Marathon is to work as many DXCC countries as possible between Saturday May 4, 2013 at 0000 UTC and Sunday August 4, 2013 at 2400 UTC on the 6-meter band. You can follow this contest online at <http://6m.dy.fi>. Go to the Six Meters Marathon 2013 rules link on the website.

ARRL June VHF QSO Party: The dates for this contest are June 8–9. Complete rules are in the May issue of *QST*. Rules can also be found on the ARRL website (http://www.arrl.org). Many are making plans to activate rare grids. For the latest information on grid expeditions, check the VHF reflector (vhf@w6yx.stanford.edu) on the internet. For weeks in the run up to the contest postings are made on the VHF reflector announcing Rover operations and grid expeditions. It is a contest that will create for you plenty of opportunities to introduce the hobby to those who are not presently working the VHF-plus bands or who are not hams.

SMIRK Contest: The Six Meter International Radio Klub (SMIRK) will hold its annual contest from 0000 UT Saturday June 15 until 2400 UT June 16. Contacts must be made on the 50-MHz (6-meter) band. Any licensed amateur in any country may participate. Exchange is grid square and SMIRK Number for operators who have one. Points are 1 for contacts with stations not having SMIRK Numbers and 2 points for contacts with stations having SMIRK numbers. Logs should go to the Secretary, Paul (Mick) McBride, W3FJ, 10 Longview Dr., Williamsport, PA 17701, or via e-mail to <mickpdm@hotmail.com>. They must be received by August 1, 2013. More information can be found at: <http://www.smirk.org/contest.html>.

Field Day: ARRL's classic Field Day will be held June 22–23. Complete rules for this contest can also be found in *QST* and on the ARRL website: <http://www.arrl.org>. In years past tremendous European openings have occurred on 6 meters. Also, as happened in 1998, tremendous sporadic-*E* openings can occur. Certainly, this is one of the best club-related events to involve new people in the hobby.

CQ WW VHF Contest: This year's CQ WW VHF Contest will be held from 1800 UTC July 20 to 2100 UTC July 21. Complete rules can be found on page 70 in this issue of *CQ VHF*.

August: There are two important contests this month: The **ARRL UHF and Above Contest** is scheduled for August 3-4. Complete rules can be found in the July issue of *QST*. The first weekend of the **ARRL 10 GHz and Above Cumulative Contest** is scheduled for August 17–18. The second weekend is September 21–22. Complete rules for this contest also can be found in the July issue of *QST*.

Quarterly Calendar

May 2	Last quarter Moon
May 5	η *Aquarids* meteor shower peak.
May 9	New Moon
May 10	Annular solar eclipse will be visible in Australia, New Zealand, & Central Pacific
May 11-12	Third Weekend of DUBUS EME Contest
May 13	Moon apogee
May 17	First quarter Moon
May 17-19	The Dayton Hamvention®
May 18-19	Fourth Weekend of DUBUS EME Contest
May 24	Full Moon
May 25	Penumbral lunar eclipse will be visible in the Americas and Africa
May 26	Moon perigee
May 31	Last quarter Moon
June 8	New Moon
June 9	Moon apogee
June 8-9	ARRL June VHF QSO Party
June 15-16	Fifth Weekend of DUBUS EME Contest. SMIRK Contest
June 16	First quarter Moon
June 23	Full Moon
June 22-23	ARRL Field Day
June 23	Moon perigee
June 27	June *Boötids* meteor shower peak.
June 29	Last quarter Moon.
June 29-30	Sixth Weekend of DUBUS EME Contest
July 7	Moon apogee
July 8	New Moon
July 15	First quarter Moon
July 20-21	CQWW VHF Contest
July 21	Moon perigee
July 22	Full Moon
July 28	Southern Delta *Aquarids* meteor shower
July 29	Last quarter Moon
August 3	Moon apogee
August 3-4	ARRL UHF and Above Contest
August 6	New Moon
August 12	*Perseids* Meteor Shower predicted peak.
August 14	First quarter Moon
August 17-18	First weekend ARRL 10 GHz and Above Cumulative Contest
August 19	Moon perigee
August 20	Full Moon
August 28	Last quarter Moon
August 30	Moon apogee

Current Conferences and Conventions

May: Dayton Hamvention®will be held as usual at the Hara Arena in Dayton, Ohio, May 17–19. For more information, see: <http://www.hamvention.org>. As usual, TAPR and AMSAT are sponsoring a joint banquet on Friday evening. For more information, see the AMSAT website: <http://www.amsat.org>. At the same time the Weak Signal Group is sponsoring a banquet. For more information, contact Tony Emanuele, WA8RJF, at: <wa8rjf@arrl.org>.

June: The annual **Ham-Com Hamfest** will be held June 7–8, in Plano, TX. As always, the North Texas Microwave Society will present a microwave forum. For details, see the Ham-Com website at <http://www.hamcom.org/>.

July: This year's **Central States VHF Society Conference** will be held July 25–27, in Elk Grove Village, at the Elk Grove Village Holiday Inn, IL. For more information, see the Society's URL: <http://www.csvhfs.org/>.

August: The annual **Huntsville, Alabama, Hamfest** will be August 17–18 in the usual South Hall of the convention center. There are several VHF-related forums scheduled. For more information, see: <http://www.hamfest.org/>.

Calls for Papers

Calls for papers are issued in advance of forthcoming conferences either for presenters to be speakers, or for papers to be published in the conferences' *Proceedings*, or both. For more information, questions about format, media, hardcopy, email, etc., contact the person listed with the announcement. The following have announced calls for papers for their forthcoming events:

Central States VHF Society Conference: Technical papers are solicited for the 47th annual Central States VHF Society Conference to be held in Elk Grove Village, Illinois, at the Elk Grove Village Holliday Inn. Deadline for submission to the *Proceedings* is May 24. For more information see the society's website: <http://www.csvhfs.org/2013conference/2013callforpapers.html>.

Microwave Update: Technical papers are solicited for Microwave Update 2013 conference to be held at Morehead State University, Morehead, KY, October 18–19. Questions concerning submissions to the *Proceedings* are to be sent to Steve Kostro, N2CEI, at: <n2cei@downeastmicrowave.com>.

Meteor Showers

May minor showers include the following and their possible radio peaks: η-*Lyrids*, May 8; ε-*Arietids*, May 9; May *Arietids*, May 16; and *o-Cetids*, May 20.

June: June minor showers include the following and their possible radio peaks: June *Arietids*, June 7*; *zeta-Perseids*, June 9*; June *Boötids*, June 27; and *β-Taurids*, June 28. An asterisk (*) indicates that the shower may have multiple peaks.

July: This month there are a number of minor showers. The *Piscis Austrinids* is expected to peak July 28. The δ-*Aquariids*, is a southern latitude shower. It has produced in excess of 20 meteors per hour in the past. Its predicted peak is around July 30. The α-*Capricornids* also is expected to peak on July 30.

August: Beginning around July 17 and lasting until approximately August 24, you will see activity tied to the *Perseids* meteor shower. Its predicted peak is August 12, 2012 between 0715-0915 UTC. The κ-*Cygnids* meteor shower is expected to peak on August 17. The α-*Aurigids* is expected to peak around September 1.

For more information on the above meteor shower predictions see Tomas Hood, NW7US's "VHF Propagation" column elsewhere in this issue. Also visit the International Meteor Organization's website: <http://www.imo.net/files/data/calendar/cal2013.pdf>.

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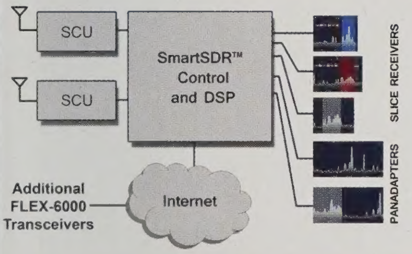
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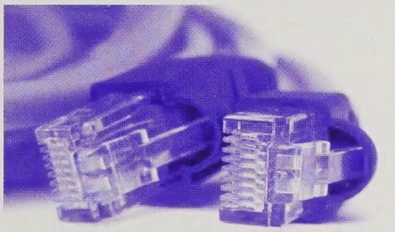

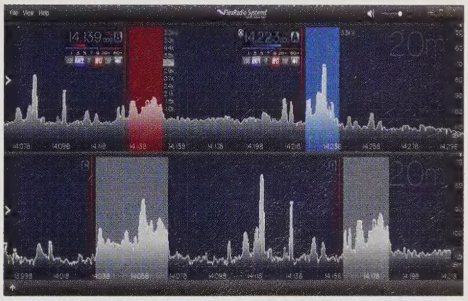

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A Student Front-Row Seat to History: Flying with Felix Baumgartner

Rarely, we might find ouselves in the right place at the right time. So it was for a group of students from Quest for Stars: They were present for Felix Baumgartner's unprecedented, record-breaking jump from space. Not only were they present, but also was their balloon with equipment in the payload that witnessed and recorded part of Baumgartner's history-making leap. Here, KJ6NKA tells their serendipitous story.

By Bobby Russell,* KJ6NKA

It might seem like any other Sunday, but today history would be made. The day was Sunday, October 14, 2012, and the Sun would be coming up soon. When it did, Felix Baumgartner would be jumping from the edge of space on a mission to become the first human to break the sound barrier without a vehicle. Colonel Joseph Kittinger came close during "Project Excelsior" in 1960 but missed the mark by just a "smidgeon," as my dad would say. Joe's record-setting jump from 102,800 feet and associated records are formidable (some died trying to break them). Joe's records still stand today after 52 years! Please see Wikipedia's writeup at <http://en.wikipedia.org/wiki/Joseph_Kittinger> for more information on Kittinger and Project Excelsior.

Diving into History

Our student team was on a mission—a High-Altitude Special-Ops Mission, to be precise. It was 12:03 a.m. and we had just arrived in Roswell, New Mexico with our caravan team. We were happy to be in Roswell and could feel the brewing excitement. Electricity filled the air even after a 22-hour drive from southern California.

Our first stop was the Roswell International Air Centre to see the Red Bull STRATOS setup (photo 1). It was the reward for working six straight weekends to perfect our new ground-control station (photo 2). The new Ground Control Station System (SS-GCS, photo 3) was designed for use with our experimental UAV StratoShuttle. The SS-GCS provided two-way telemetry, live downlink FPV video or stills, and full remote control of the UAV. Telematics for SS-GCS utilized the 433-MHz, 900-MHz, and 1200-MHz bands. On this day we were putting it to another cool use—flying beside Felix Baumgartner as he ascended to the edge of space! The countdown clock was running and just passing the T-5 hours to liftoff. It was on!

Back to the Future

How did we get to this point? To tell this story, we must rewind for a moment. It was July 2010. Quest for Stars was preparing for its first flight to the edge of space, Droid-1 (see "Chasing Discovery—Part 1," by John Pugh, KJ4YNE, pp. 10–13, Fall 2011 *CQ VHF* magazine). As a newly minted 501c(3) non-profit focused on science and technology, we contacted Red Bull® to see if it was interested in sponsoring educational outreach projects for students.

After a few e-mails and phone calls with their team, a pallet of sugar-free Red Bull energy drinks arrived by truck at our offices. The note attached said, "Keep up the good work! We can't sponsor any other initiatives outside of Felix's jump for now. Enjoy the Red Bull and keep us posted on your progress. You guys rock!" That was the last contact we had with Red Bull. Our e-mail replies had gone quiet, and a third-party lawsuit filed against Red Bull regarding the STRATOS project made news.

Photo 1. The Red Bull STRATOS capsule as seen on Sunday morning as it was prepared for launch.

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*e-mail: <bobby.m.russell@gmail.com>

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Photo 2. The student team worked six straight weekends to get our ground control station ready for prime time.

Needless to say, we were disappointed . . . but there was a silver lining.

We ended up using that entire pallet of Red Bull energy drinks for the long hours required to photo-document the final flights of the Space Shuttle Program from student balloons. The pictures from those flights made it to the International Space Station and to NASA Headquarters. The students personally were congratulated by NASA Administrator Charles Bolden. Thus, in a sense, Red Bull had already given our program wings!

The Last Hotel Room in Town

Back in Roswell, it was now 1:30 a.m. and we had arrived at the hotel, the Candlewood Suites (photo 4). It was the only room available in town. Finding that room was lucky! The parking lot would serve as our new launch site area. We parked the vehicles in the gravel lot section against the fence of a golf-course driving range. The vehicles were parked in an L-shape formation, giving us a safe

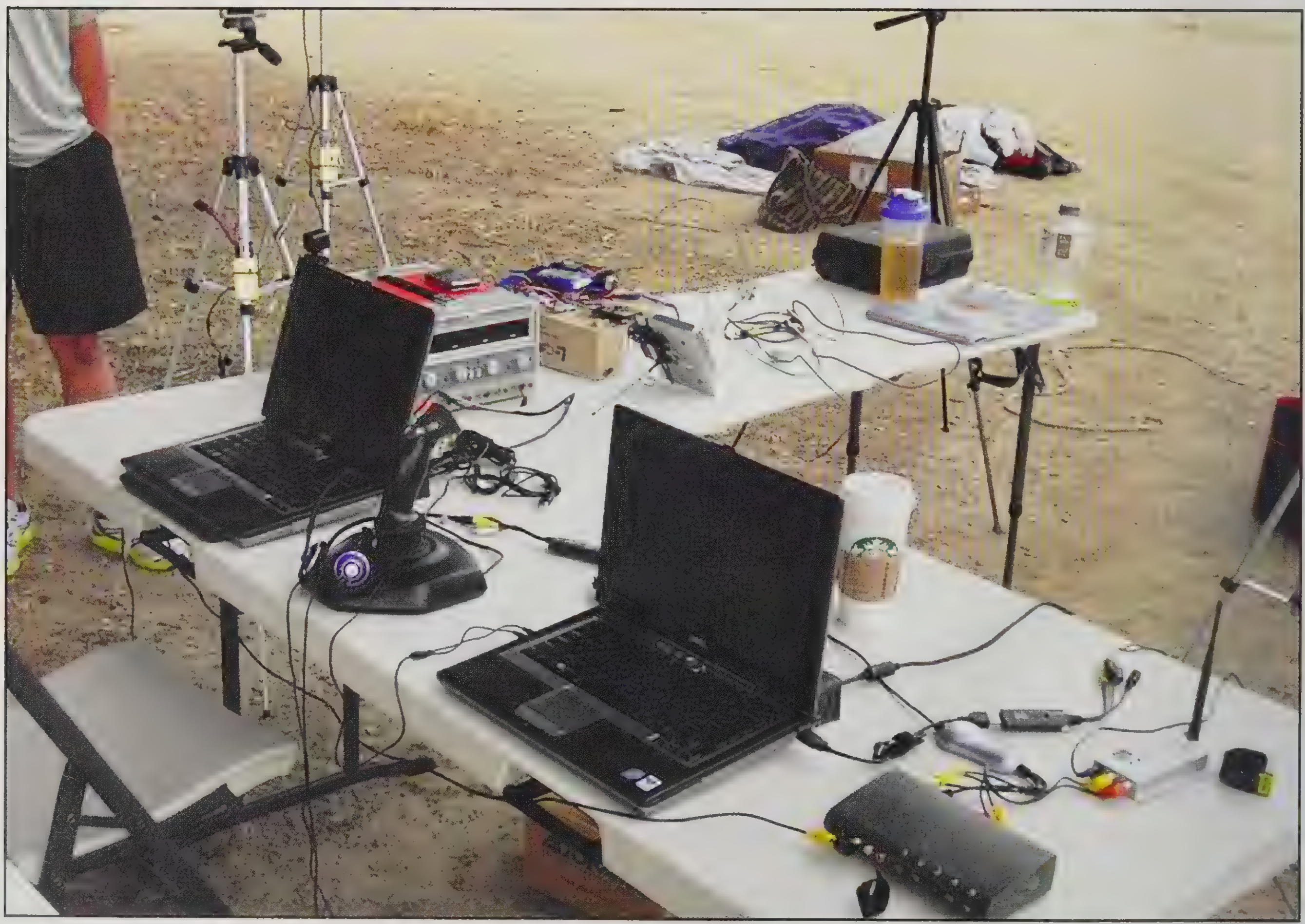

Photo 3. The Quest for Stars internet-connected ground control station system designed for our StratoShuttle UAV flights.

Photo 4. The Candlewood suites at 0300 hrs on October 14, 2012. The setup begins!

Photo 5. Felix heads to the capsule.

and defensible launch site area. I tested Wi-Fi from the hotel and turned in for a little less than an hour of sleep.

Mission First: Sleep Can Wait

About 3:00 a.m. smart-phone alarms in the crowded hotel room went off to create an interesting musical medley that played for a few minutes. It was time for setup, and with heavy eyelids we started the procedure of unloading the vehicles and setting up. STRATOS was scheduled to launch around sunrise, which would occur in a few hours. Tables were being set up and computers were coming up. The rotator was assembled and calibrated. Things were going according to plan, with the exception of a few glitches that were easily and quickly resolved.

As the clock passed 4:30 a.m., the first word of a wind delay came. Minutes later it occurred. As it turns out, the wind delay lasted all the way until the 8:45 a.m. news conference that had just been announced. It's a good thing, because we had just hit an issue with the APRS beacon losing its configuration. A simple reflash of the settings and we were ready to fly. Huddled around any heat source possible, we anxiously were awaiting the 8:45 a.m. news conference.

Go, No-Go Decision

As the 8:45 a.m. news conference began, with our anticipation, the weather briefing was up first. The STRATOS weather officer now gave the green light to fill the STRATOS balloon! Wahoo! It was a go with a launch time of 9:45 a.m. as indicated by the launch director. In the following seconds, the STRATOS balloon fill initialized at a rapid pace. The Quest for Stars team immediately dispatched Jo Jamison, a student from Citrus College, to be our on-site observer at the Roswell International Air Centre. While observing, Jo heard a mission update over the loudspeaker: Launch was imminent! She relayed the news via phone. We were puzzled as to why they would fly earlier than 9:45 a.m., but there was no time to waste. We had to get airborne, and we now were behind.

Liftoff!

The payload had been readied, and our Stratoshuttle-3 balloon was starting to take shape (see photo 5 for Felix ready to go, and photo 6). Then out of nowhere

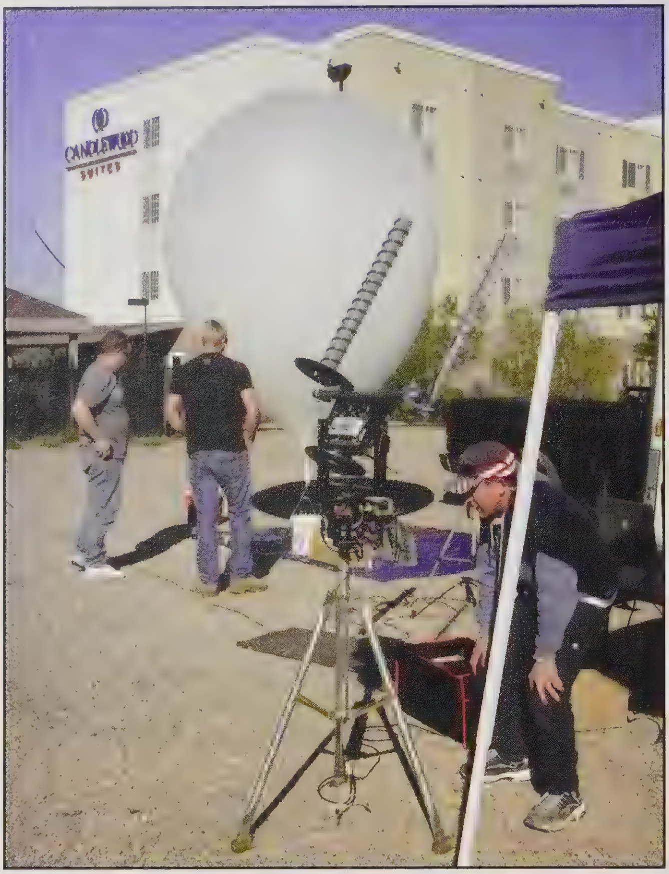

Photo 6. The ground station, rotator, and Stratoshuttle-3 balloon just before launch. Felix was in the air at this point.

Photo 8. The Red Bull Stratos balloon and Stratoshuttle-3 balloon in flight.

Photo 7. Launch of our StratoShuttle-3 balloon.

Photo 9. Jo Jamison holding her X-ray shielding experiment for a rocket project that flew onboard our flight.

someone shouted, "There's Felix!" Everyone looked up and saw the Red Bull STRATOS balloon coming straight toward us. Every second now counted for our team. Our balloon was filled and ready to fly, but there was one last problem: We had a camera that would not function. We made the decision to fly without the camera. Off came the camera and the clock ran down to zero: "Liftoff! We have Liftoff of Stratoshuttle-3 (photo 7): Paving the Way for Student UAV Research While Flying with Felix to the Edge of Space." All heads were skyward as we watched our balloon climb out. It gently settled into a formation position with Red Bull STRATOS as it approached STRATOS. We all watched in awe as our balloon flew in formation with Felix (photo 8). I broke the surreal trance to perform a systems check of the live video down link. It was working perfectly, and we had 6000+ viewers watching our USTREAM feed! That's when the real excitement began!

Chasing Felix

It was time for our chase team to depart. I elected to stay behind with Jo Jamison

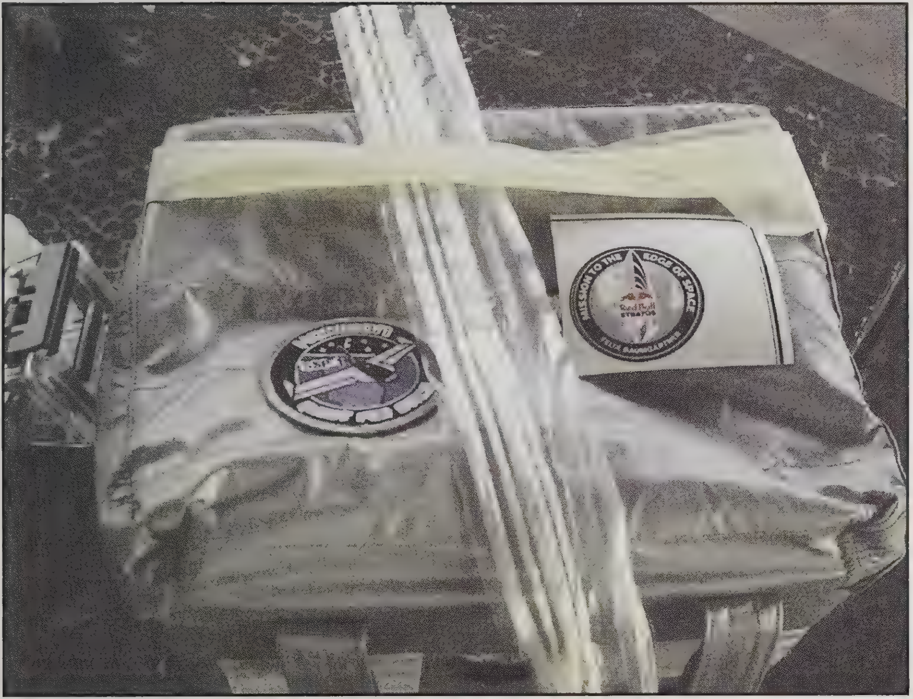

Photo 10. Inflight view of Stratoshuttle-3 payload with STRATOS balloon over the top of our balloon.

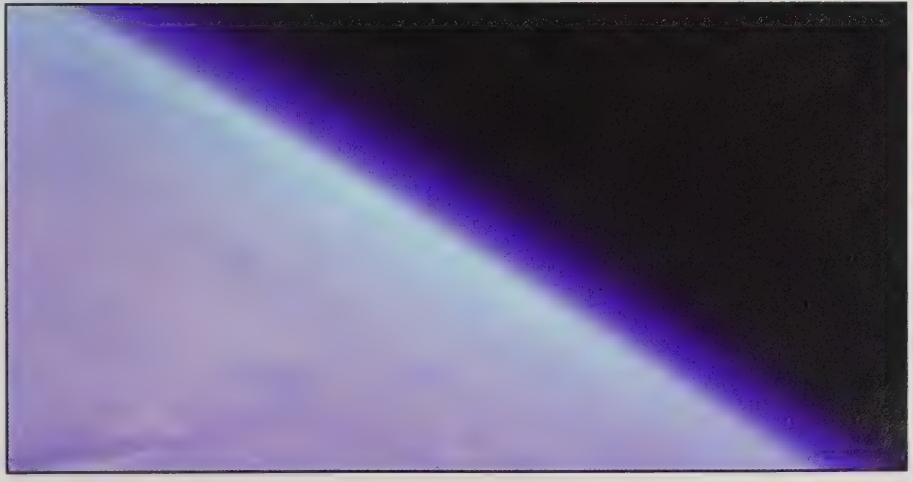

Photo 11. The edge of space from the top of our flight.

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Photo 12. Our balloon bursting at 98,000 feet.

(photo 9), who had just rejoined us from the Roswell Air Centre. Tim Geary assembled the recovery team, reviewed the route to US-380, and departed the hotel parking lot about fifteen minutes after launch. The chase plan called for following US-380 to the landing zone indicated by the forecast that morning.

A few minutes later our launch site had a few visitors who asked if we worked for Red Bull. We said no, and told them about Quest for Stars and what we were doing. They introduced themselves, and to our surprise they worked for Red Bull in Marketing and Event Production. They told us that Red Bull staff was staying at this hotel and the Holiday Inn right across the street.

We invited them to stay for the duration of our flight. The visitors were impressed with our setup. They were most impressed by our passion to inspire students. They asked lots of questions about the program. It's a good thing we like to share, because we were about to

Photo 13. Our payload about to be rescued by team Red Bull!

meet many more Red Bull team members. These team members had black helicopters at their disposal.

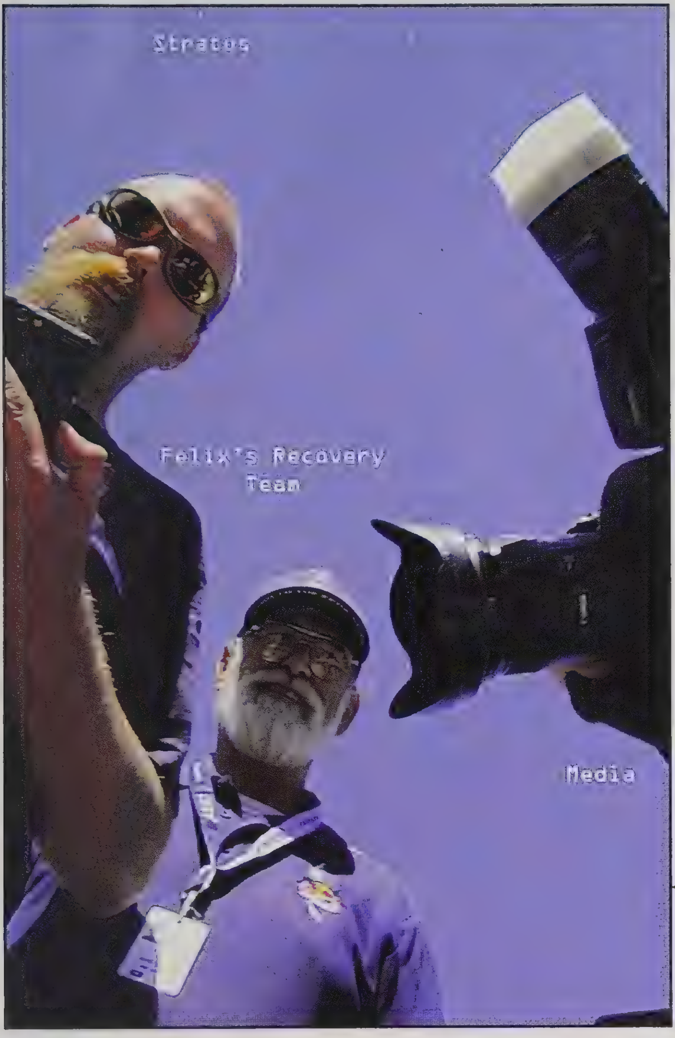
What Goes Up

We were monitoring StratoShuttle-3 and RB STRATOS in flight. SS-3 was at 96,000 feet, and Felix was passing at 80,000 feet. We realized that our balloon was out-climbing STRATOS even after they released ballast. This meant we were going to land before Felix. On the bright side, our balloon was still sending crystal-clear live video from a slant range of 85 km.

Ping! The Byonics® MT-RTG APRS beacon reported 98,000 feet. About 20 seconds later, the video from the down link experienced its first true blackout which lasted a few seconds. Our balloon had burst (photos 10, 11, and 12). The rotation at burst obscured our antenna, temporarily causing video loss. With video restored, we could see we were falling fast. I called Tim to inform him that we'd burst. Tim reported that they were not making good progress due to launch-related traffic in town and that they were 15 minutes from the landing zone. As it turns out, they were late. Minutes later, and just as planned, we landed in the forecasted landing zone. Things were about to become strangely cosmic.

A Cosmic Twist of Fate

Back at the launch site, the audio from the YouTube STRATOS live feed was blaring. We were on the edge of our seats watching Felix start the preflight checks for his jump. Suddenly, my



← *Photo 14. Red Bull and the media open our payload. Picture snapped on board StratoShuttle-3.*

Photo 15. Everyone is awaiting the sonic boom at the Red Bull Recovery Command Center. ↓

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Photo 16. Jon Wells (Red Bull Recovery Crew Chief, left) and Tim Geary (Quest for Stars Recovery Team Leader) exchange handshakes and our payload.

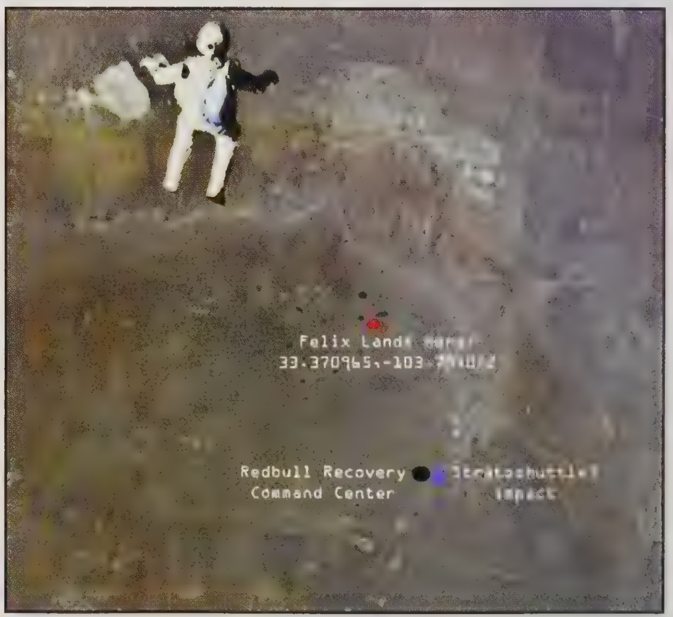
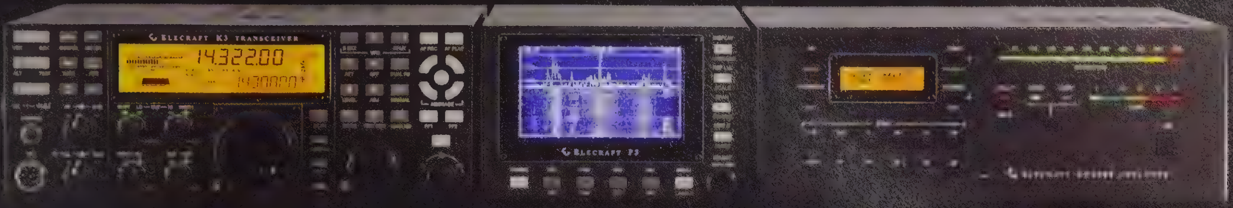


Photo 17. A nice photo to show you how close we landed to the recovery center and where Felix landed.



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cell phone rang with a number I had never seen. I almost send it to voice mail, but thankfully, I decide to answer it.

"Bobby? It's Jon Wells from the Red Bull STRATOS team. We have your payload!" (See photos 13 and 14.)

I nearly dropped the phone and did my best to contain the excitement in front of the students. Jon said he only had five minutes to spare, as Felix was about to jump. Jon was the RedBull STRATOS Recovery Chief in charge of getting Felix, the capsule, and the 3000-lb. balloon back safely. Jon had set up his Recovery Command Center at the Caprock Country Store, and we landed just across the street.

I let Jon know we appreciated the recovery of our payload and that we had a crew on the way. I saved his number and called Tim immediately. Tim answered: "Hey, man, what's up?" I responded "You're never going to believe who just called me!"

Backstage Pass

Tim and the team arrived at the Recovery Command Center with a few minutes to spare before Felix jumped. This cosmic twist of fate had given our team a front row seat to history. They got to meet the people who designed and flew the mission and hear the sound barrier being broken by Felix in descent (photo 15). Truly, our team had one of the best seats in the house. I had them take pictures of the two teams together before they returned to the hotel (photo 16). Mission accomplished (photo 17)!

Later that night the after-party at the hotel pool kicked into high gear. We were invited to mingle with the staff and took pictures. We displayed our payload for all to see. Jon Wells iced the cake by giving us a large piece of the actual STRATOS balloon. We proudly displayed it on top of our payload that night. To date, we also have shared it with hundreds of students. It was cool to become Honorary Red Bull STRATOS Team members for the day. The only thing that topped that was the smiles on student faces.

Going the Distance

After the Roswell Mission we were looking to keep the energy from that chance encounter going strong. To that end, we are proud to announce the Strato-Eminus Competition. It's a distance competition in which students design and build foam replicas of Felix's STRATOS capsule. The goal of the contest is a flight a distance of 10,000 miles. The prototype Eminus capsule contains a Byonics MT-RTG modified by removing the 7812 regulator, adding a CMOS flip flop for external configuration switching, adding a CMOS transistor for GPS power control, and a power source designed for eight days of flight. Future options will include auto-frequency switching based on Arduino GPS parsing. Our goal is to have students own these records and to conduct this competition every year as part of the Quest for Stars program.

Making the practical application of technology cool and exciting is the best way to inspire the next generation. Help us make a difference in more students' lives by supporting missions like this one. Join the quest by following us or donating today!

Sources of More Information

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Working Satellites with a Homebrew Setup Cuban Style

Lack of equipment. Lack of parts. Restrictions on frequency spectrum . . . None of these limitations has deterred CO6CBF from working satellites from Cuba. In this article, he tells the fascinating story of how he has come to be able to work the birds from CO-land.

By Hector L. Martinez,* CO6CBF

Since the time I first heard about SuitSat-1 from the National Television of my country, I was encouraged to do research about it, ARISS, and space communications in general. I had not heard about this part of our hobby before. I was really surprised when I discovered the great amateur radio activity that exists in space. At that time, I was 15 years old and was studying at the electronics technician school of my city. I got my first radio license at 11 years old as CL9CBF, and built my first 160-meter transceiver following the instructions from Raul Gomez, CO6GB, a radio operator of my radio club. I was very active on 160 meters.

The only radio available for satellite work was a broken 2-meter Yaesu FT-23R HT that my grandfather bought for me. I fixed it, following the instructions from Javier Herrera, CM6WB (now CO6WB), another ham of my radio club. I tried to receive SuitSat-1 using this radio and a homebrew 6-element Yagi that I made to operate through the local repeaters. As I had been studying about antennas for satellites, I bent the Yagi's boom skyward and moved the small tower in front of my shack's window, ready to point it by hand through the window.

At the same time, I was trying to build my first PC with recycled parts. It was ready for SuitSat-1, running an unregistered version of WXtrack on Windows® 98. Despite not hearing anything from the spacecraft, it was a great experience for me. Looking for information about it, I learned about the marvelous world of AMSAT and the space projects that involved amateur radio.

I built the interface to connect the FT-23R to the computer and made

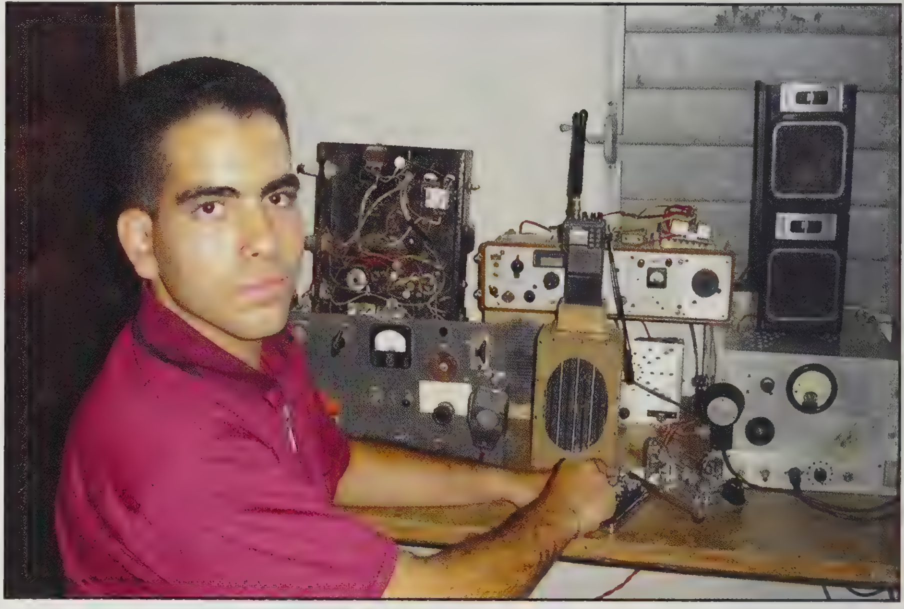

Photo 1. My first radios

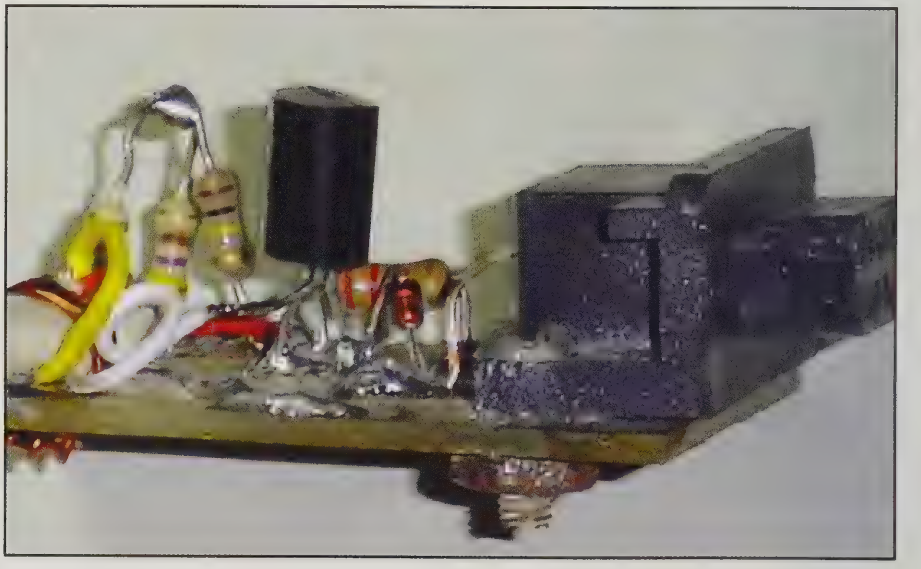

Photo 2. My first interface

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*e-mail: <co6cbf@amsat.org>

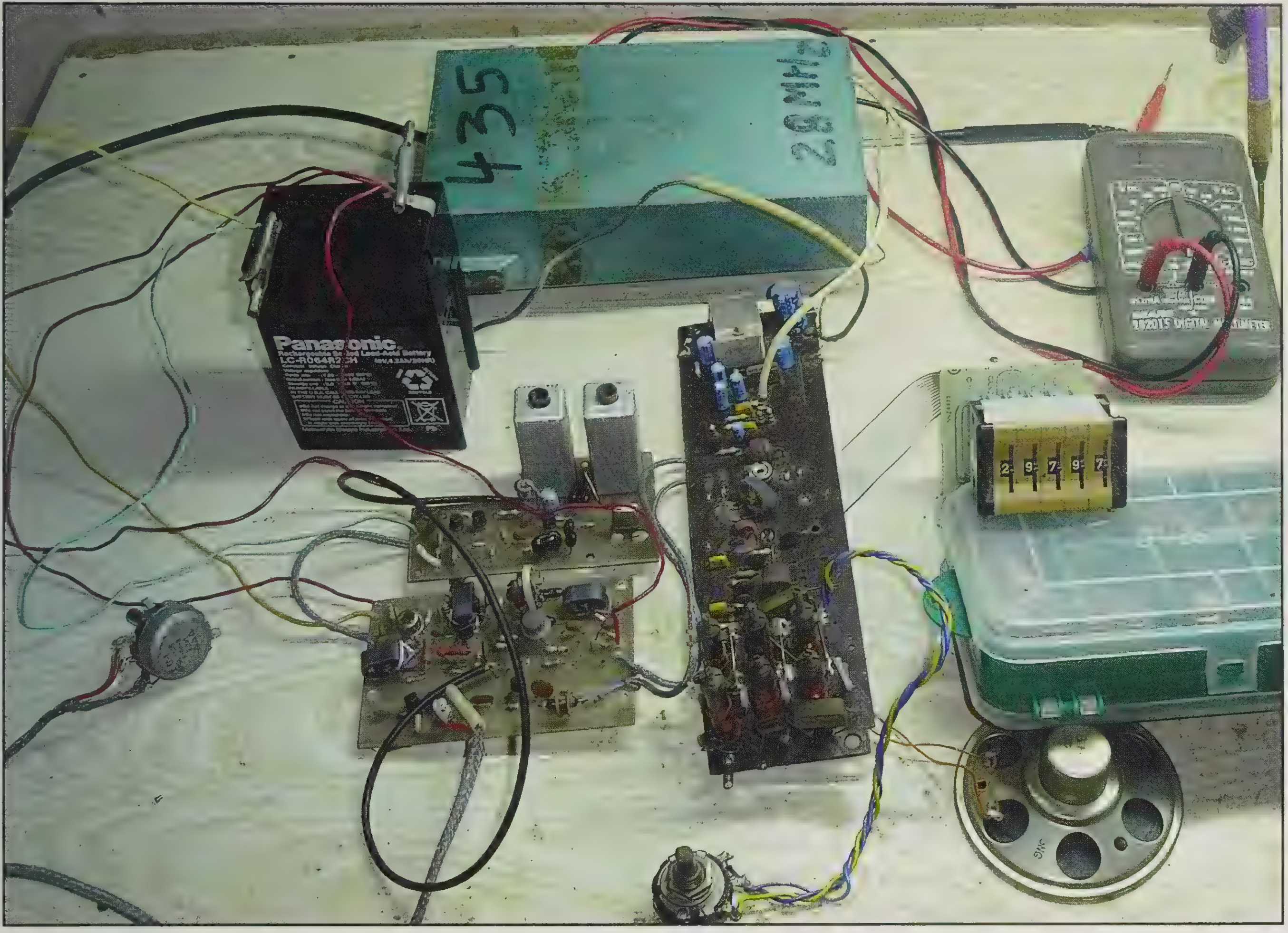

Photo 3. Testing the transverter

everything to work the ISS digipeater. The first signal seen on the screen was from Jose Luis Castillo, YV6BFE. I also tried to receive the meteorological pictures from the NOAA weather satellites. After some weeks, I had my first contact with the International Space Station's crew. An unforgettable moment in my life!

At that time, I kept in mind that operating through the satellite transponders was impossible for me. I never had seen any 70-cm radio, or any UHF homebrew radio project. I had not known any satellite operator in my country.

My First Satellite Setup

When I finished the technician school, I began to work as an electronics technician. I had my own e-mail and an Internet account. I continued looking for any 70-cm radio or any UHF scanner, but it has been really difficult for me to find one. There are no shops or RadioShack stores available to buy anything related to amateur radio.

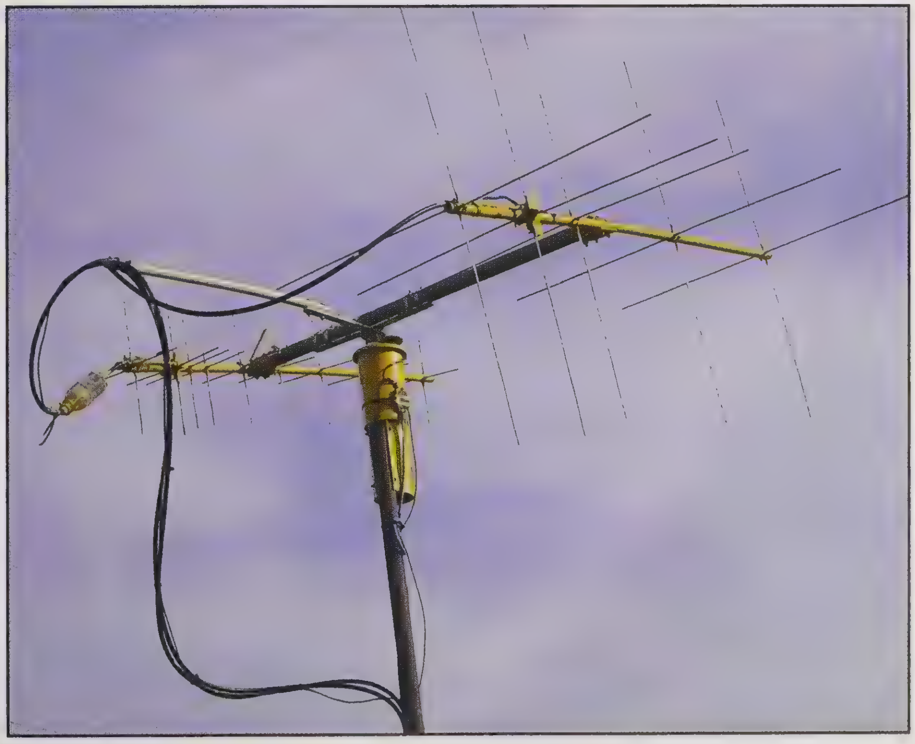

Photo 4. Yagis, rotor ,and preamplifier

I found some 70-cm downconverter designs online and asked for help on some e-mail lists about any other designs in order to choose the most complete and achievable project. This one came from Bill Zurilla, NZ5N, who sent me an article entitled "Make Mine Modular: Easy-to-Build Receiving Converter and Test Equipment for 435 MHz," by John Reed, W6IOJ, which was published in the March 1983 issue of *QST*. It is a great project with a detailed "know-how"!

Because the project doesn't require highly sophisticated test equipment for alignment, the article itself shows how to build the needed test equipment. Even though this was written in 1983, it was still relevant for me. While there are plenty of high-performance downconverters, most of the parts required to build them are not available in my country. It was just what I was looking for!

I constructed everything carefully, as John described, beginning with the test equipment. All the electronic parts were found in my "junk box" and in a broken Yaesu FTC-2640 2-meter radio. I did not have a printed circuit board to make the circuits, so I built it in three TV tuner boxes without circuit board. I used a box for each module—local oscillator, mixer, and RF amplifier. This method made the project very easy to assemble. It was my first UHF homebrew construction, and I cannot say how satisfied I was when I tested each module and everything worked properly.

I had thoughts about antennas, too. While I was working on the converter, my grandfather, who is a very smart mechanic, was building some pieces to rebuild a blood pump's motor reducer from a discontinued dialysis machine. We used it as the main part for the azimuth rotor. I designed the circuits for the position reference and the remote-control box. The rotor-control box was constructed into a FAX modem case.

I designed two circularly polarized Yagis, 18 elements for UHF and 10 elements for VHF. I simulated and optimized these in software called MMANA, and the project was ready to be built. The calculations were done for the parts that I had in my junk box. I used 30-mm PVC pipe for the booms, and for the elements 4-mm aluminum wire. The transmission lines were RG-58 coaxial cable.

The rotor and antennas were assembled in my backyard at four feet over the ground to test its performance before going on the roof. The system was tested and it worked as was expected. Thus, I had everything ready for the "smoke test," my first satellite contact.

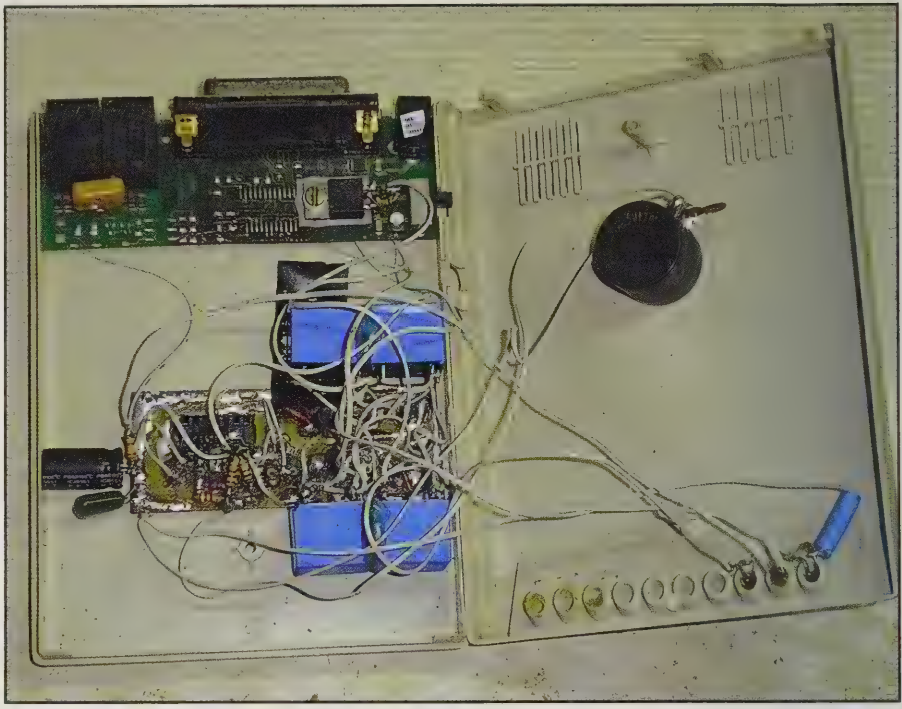

Photo 5. Inside the rotor control box

My first satellite contact was on January 27, 2011, with John Papay, K8YSE, on AO- 51, which was another unforgettable moment in my life! After that, I spent around two months working on the tower and the UHF preamplifier. I chose a mast-mounted DF9CY preamplifier design and built it into a TV splitter case. It was tested with the same equipment built for aligning the converter.

We installed the rotor, antennas, and preamplifier on the tower. Since that moment, I have been on satellites almost every day!

First Portable Operation

After about a year on the FM birds, I obtained the first satellite VUCC in my country and other AMSAT awards. This was a great accomplishment for me. While I was very active on satellites from home, I was improving my FM setup until I could carry it in my backpack. I constructed a YO3BAL 70-cm/2-meter downconverter, which spent a long time at the workbench due to the poor description of the design I had and the inappropriate circuit-board material I used. Finally, I got it performing properly, but it did not perform as well as my 70-cm/10-meter converter.

I rebuilt an SSB HF receiver which I made for other uses as a FM 10-meter receiver. I tried to reduce the weight and size as much as I could. When the work was finished, I tested it together with the 70-cm/10-meter converter. Its performance was very good.

In August 2011, my brother Franklin Breton Sis, CL6BFC, my girlfriend, and I planned a vacation trip to Trinidad city and Rio Hondo. I thought it would be a great opportunity to do the "smoke test" with my portable setup and activate a rare grid square. I made an IOio antenna and tested the system from home trying to receive AO-51 running both configurations:

IOio antenna, 70-cm/2-meter downconverter, 2-meter HT

IOio antenna, 70-cm/10-meter downconverter, HF receiver

The second configuration worked better, but it was a little more complicated to use without any assistance.

Finally, I carried the two configurations and a 12-V, 7-A gel-cell battery to power the system. It was my first portable operation on satellites, and it was fantastic. I operated from the EL91/FL01 grid boundary and used both configura-

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tions. During the very early morning AO-51 passes around 5:30 a.m., I woke up and used the first configuration with limited RX capabilities. During the afternoon passes, I used the better gear with the assistance of my brother and my girlfriend. We had 20 contacts in four AO-51 passes, and we operated from two grids never activated on satellites!

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Photo 6. Outside cover of the rotor control box

SSB Satellite Setup

Since I set my eyes on the linear birds, I had been looking for any 2-meter multimode radio. Once again, it has been really difficult to find one.

I tried to convert an old 2-meter FM transceiver into a CW transmitter. I disconnected the MIC preamplifier circuit, kept the TX activated, and switched the RF drive transistor by a switch circuit added and commanded by the CW key. The experiment worked successfully, and I had my first contact on AO-7 mode A on April 24, 2011 with Gary Fowks, K4MF.

Thinking about something more serious, I began to find information about any homebrew SSB 2-meter transceiver or transverter project to complete my gear for the linear birds. I found some interesting and detailed projects online from Gaetan Horlin, ON4KHG, and Janne Pulkkinen, OH1SDR, but most of the parts required to build them are not available in my country.

The most achievable 2-meter transverter project came from Manuel Gaibisso, CX9BT. He designed and constructed it for EME purposes. The project looked wonderful, and I had the opportunity to chat directly with him by e-mail and radio on the 10-meter band. The project required some specific parts: the MC145151 synthesizer, SP4541 prescaler, PIN diodes, mixer DBL, 5W hybrid power amplifier, some GaAsFETs, and some dual-gate FETs which are not available in my country. Manuel sent me all these parts and some others for future projects!

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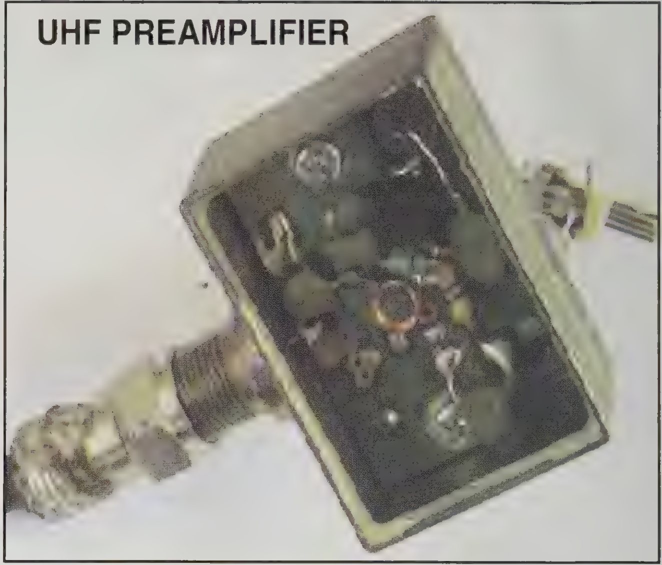

Photo 7A. UHF preamplifier with cover off

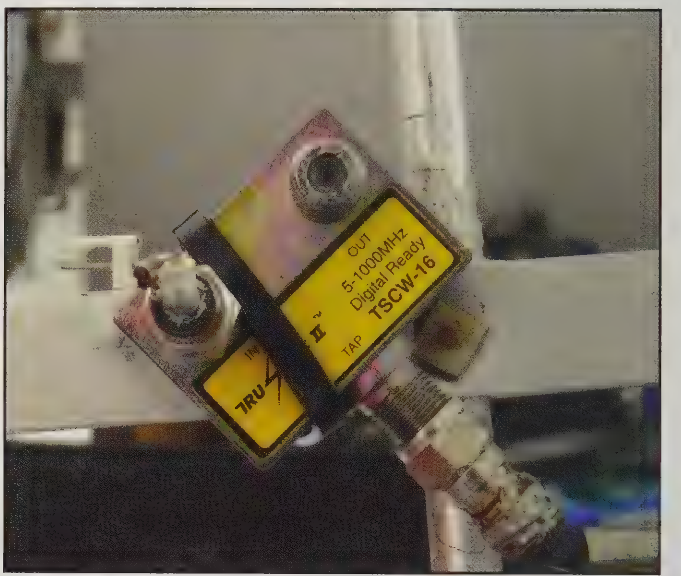

Photo 7B: UHF preamplifier mounted on the antenna

I started to construct the transverter and was testing circuit by circuit as Manuel was telling me. It was really difficult for me to fix the synthesizer exactly at 116.00 MHz. The project was constructed in a discontinued PH meter laboratory instrument case. When the transverter was finished and aligned, I did the "smoke test" on FO-29. My first contact was on January 31, 2012 with Robert Dickey, AK5V.

When I finished the transverter, I listened for VO-52 and I was surprised at the great signals coming from the transponder and beacon. I was encouraged to work on another project to add the transmission stages for my first 70-cm/10-meter down converter. I had to modify the original project, but it was not difficult, as the main part was done before. I modified the same CX9BT design with some references taken from the JF1OZL 70-cm transceiver project. I built the switch stages, attenuation stage, bandpass filter, and power amplifier. The majority of the electronic parts were found in my junk box.

Photo 8. 70-cm down converter plus Yaesu FT-23R HT

The few remaining items, such as high-Q trimmers and high-frequency low-noise transistors were impossible to find here, but were donated by Bill Blazina, W3XS.

I had my first contact with VO-52 on February 28, 2012 with Walter Mercado-Vazquez, WP4T. I was running around a watt, and Walter gave me a 57 signal report!

Current Satellite Gear and Future Projects

In order to improve the Intermediate frequency stability for the transverters, I bought a Yaesu FT-757GXII in good shape but with some transmission issues. I researched it and looked for any assistance 0n the Fox Tango International website. This time help came from Carol Maher, W4CLM, and David Hoisington, W6NFU. I substituted all the switching diodes in the RF board as they told me, but the problem with the RF power continued, so I decided to substitute the TX mixer IC (ND487), which has four diodes. I matched four BAT 41 diodes and connected these under the circuit board to try the RF power level again. Fortunately, the radio was fixed! It is my first commercially-made ham radio!

When I am at home, I combine the 757 with my homebrew transverters, which is a great advance among my homebrew HF transceivers. Now I am able to tune FM in 2.5-kHz steps, which is a great help to receive SO-50.

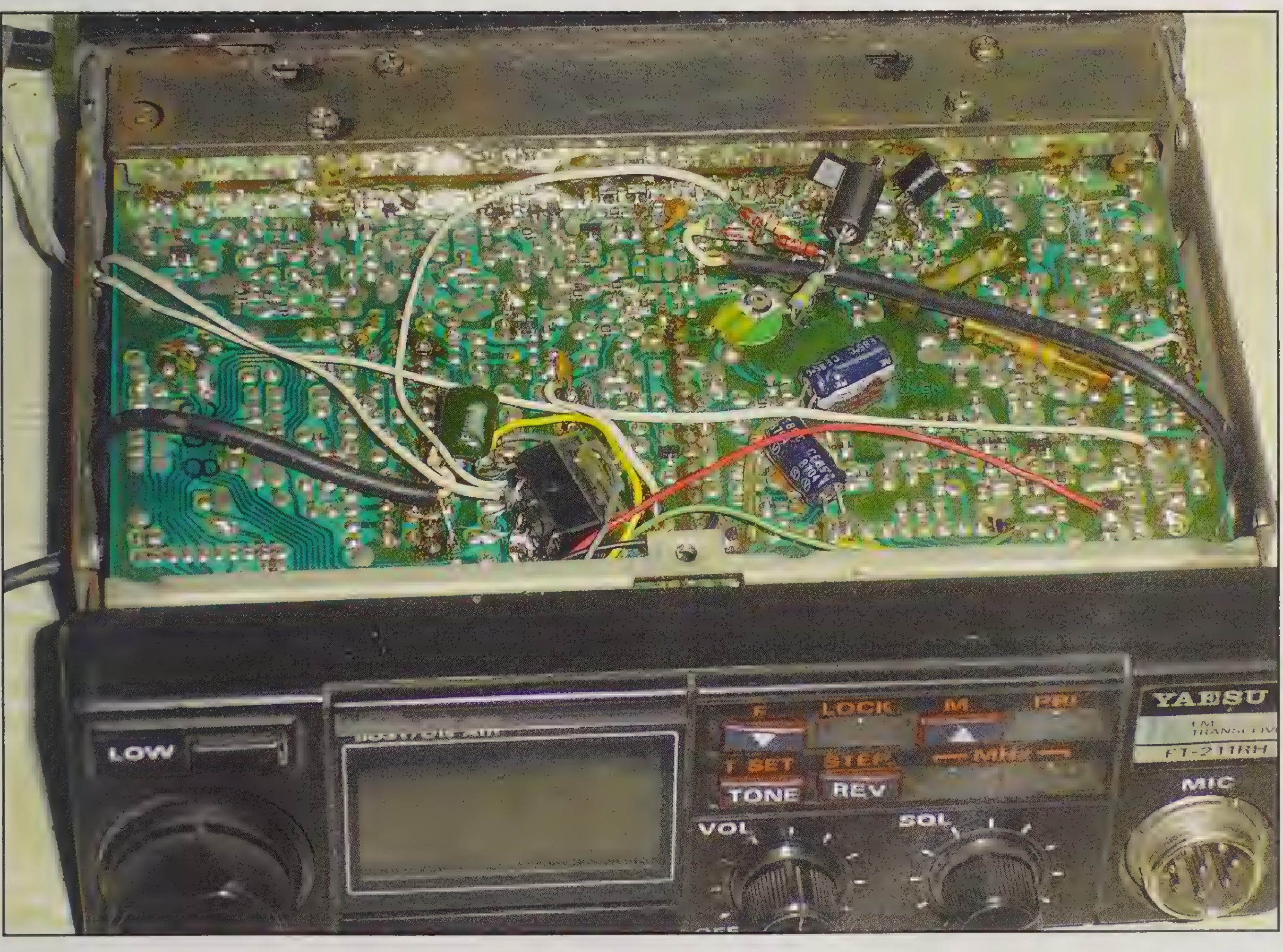

Photo 9. 2-meter FM transceiver converted to CW transmitter

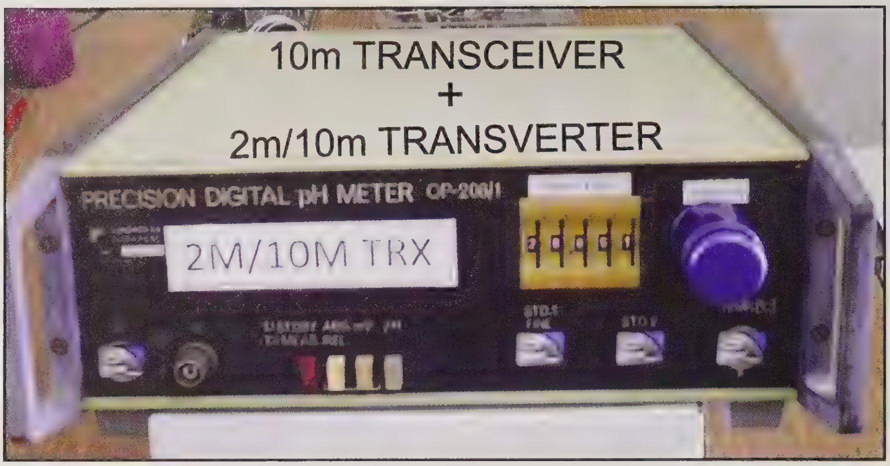

Photo 10. 10-meter transceiver plus 2-meter/10-meter transverter

My local area is very hot. I live in the city, which has a lot of buildings with amateur, broadcasting, repeater, and other stations. Therefore, I constructed a cavity preamplifier that Domenico Marini, I8CVS, described in a great Italian article. Before that, I had TV interference on the downlinks of SO-50 and AO-27. When I began to use the preamplifier, the interference disappeared. It allows me an excellent full-duplex capability without desense problems.

In order to handle my portable gear easier, I found a great solution: I installed the YO3BAL 70-cm/2-meter downconverter inside a mobile 2-meter radio that had a damaged transmitter. I removed it and then installed the downconverter. Now it is easier to operate from anywhere. I hold the 2-meter FM mobile radio with a strap around my neck, the HT in one hand. and the homebrew Arrow™-type antenna with preamplifier in the other hand. I use a 2-meter Kenwood TK-270 handie-talkie for transmitting, a 12-V 7-A gel-cell battery in a backpack to power up everything, plus a portable digital MP3 recorder to log the contacts.

I tested some preamplifiers on my homebrew Arrow™-type antenna, including a PR40 kit that was donated by Omar Cardenas, XE1AO. The preamplifier on the Arrow improved my capabilities to receive the satellites during my portable operations. I worked Yuri Bodrov, UT1FG/MM on AO-27 with under a degree of elevation!

I am preparing to improve my station to work FO-29 on the horizon. Cubans cannot operate on 432 MHz (AO-7's uplink), so FO-29 is the only chance to reach long distances on the satellites.

I am constructing a 2-meter 50-W linear PA and two long Yagis, M^2's 2MCP14 and 436CP30. I am trying to

First Cuba to EI Contact on FO-29

The following is from AMSAT-UK (http://www.amsat-uk.org):

Hector Martinez, CO6CBF, in Cuba has worked Joe Murphy, EI5EV, in County Kilkenny, Ireland (grid square 1062) on the amateur radio satellite FO-29 over a distance of 6955.1 km.

Hector writes: "I am pleased to report that today I had my first contact on satellites with Ireland.

Joe Murphy, EI5EV, and I completed it successfully on FO-29. We had just a 66-second window, but there was enough time to exchange reports and greetings. I believe that it is the first contact between Ireland and Cuba on FO-29! It is a 4321.7-mile (6955.1-km) contact!

Our first attempt was the day before, but Joe couldn't find me on the passband. We made a schedule again and we tried to be more accurate on frequency calculations. Doppler is always in play!

We did the calculations based on the great feature implemented on SatPC32 V12.8b. There is an option of seeing the frequency you are at the satellite receiver. This was our common reference point. I was very satisfied when I heard Joe exactly on the frequency I was expecting!

I was operating portable from a tall building's roof, which allowed me a great horizon visibility toward Europe. I was running my new FT-817, a 30W power amplifier, and a homebrew Arrow antenna with a homebrew mast-mounted preamplifier. Everything was supplied by two 12V 7A gel-cell batteries.

CO6CBF working EI5EV on FO-29, April 3, 2013, a 4321-mile contact!

Right now, FO-29 has a big footprint. Please, if you are in the footprint and want to try a long-distance contact, just drop me an e-mail. I will try to complete a contact with you.

Thanks very much to Joe, EI5EV, for this great contact!

73! Hector Martinez, CO6CBF, El92sd
e-mail: <co6cbf@frcuba.co.cu>
FO-29 information: <http://amsat-uk.org/satellites/fuji-oscar-29-jas-2/>

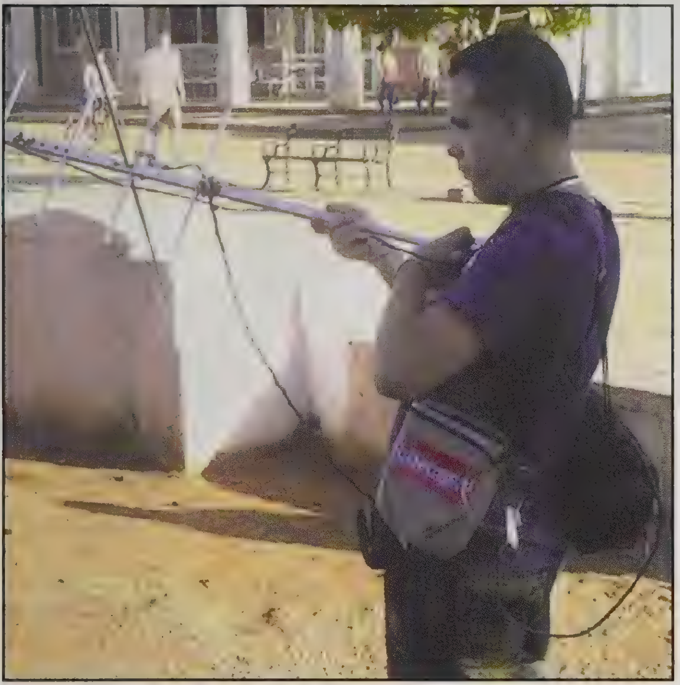

Photo 11. Satellite presentation from Aguada town

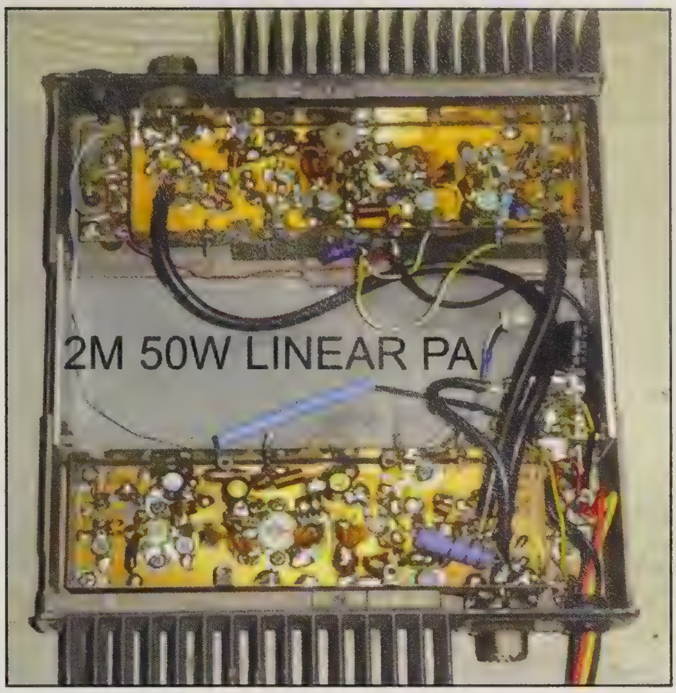

Photo 13. Two-meter linear power amplifier

Photo 12. Portable gear

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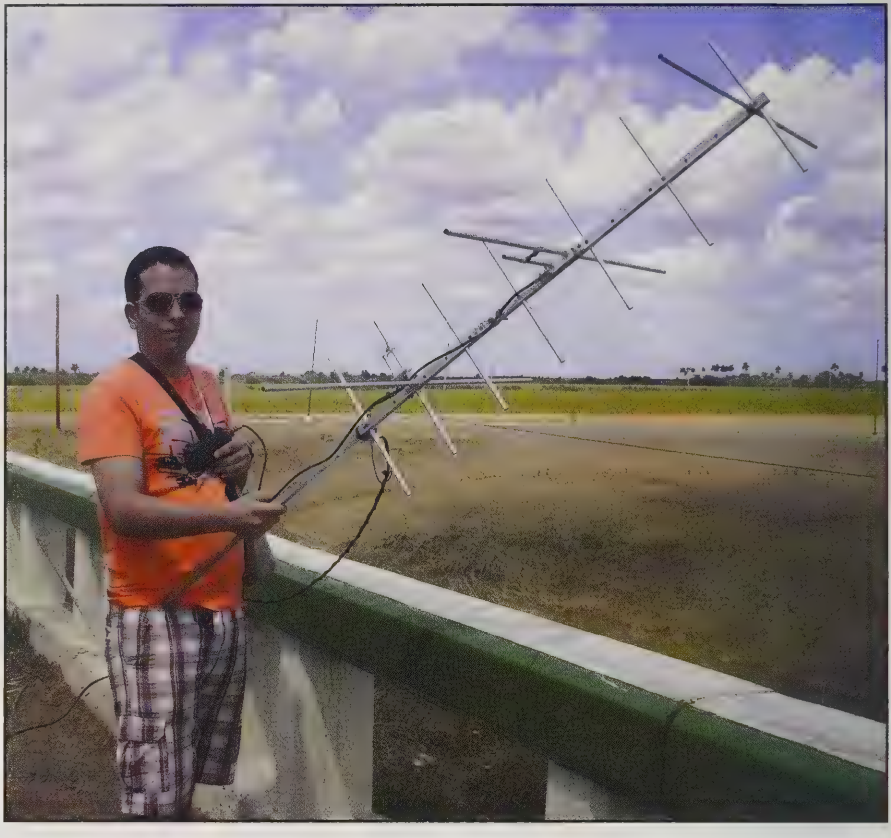


Photo 14. EL92 operation

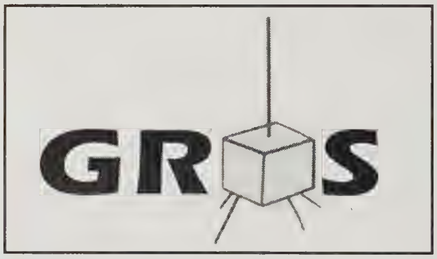


Photo 15. Cuban Satellite Group (GROS) logo.

add the elevation capabilities to my homebrew rotator, keeping in mind the local availability of pieces that we recycle from many sources. I plan to install the antennas at 95 feet on a nearby building.

Summary

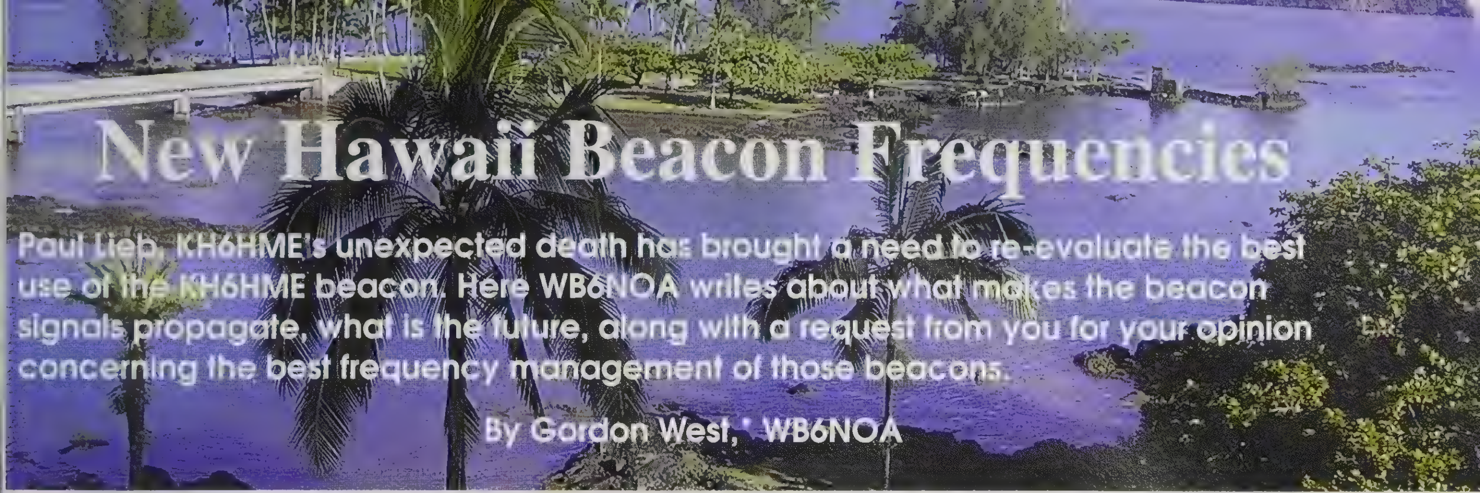
I have spent a long time at the workbench constructing my gear for satellites. It has been a really long time, but I have enjoyed it!

I have worked 49 of 50 US states and 487 grids squares. I have operated from six Cuban grid squares (EL83, EL91, EL92, EL93, FL01, and FL02); most of them have never been active on the satellites. In less than two years on satellites, I can see 4460 contacts in my log!

Here in Cuba, there are only a few satellite operators. The amateur satellites are a strange world for the majority of Cuban hams. In order to promote Amateur Radio by Satellite, we formed the first Cuban Satellite Group (GROS). We are trying to encourage operators to join us on this fascinating ride. We have done several satellite presentations to radio clubs, universities, high schools, and parks. We have won a lot of satellite enthusiasts.

My hope is not only to involve more hams to contact satellites, but also to motivate young people today toward careers in science, math, and technology. I will never forget my first time hearing myself on the transponder downlink. Even though it was almost two years ago, my heart is still excited when I hear myself on the downlink!

I want to say thank you to all my friends who have helped me in my ham radio satellite hobby. I am very fortunate to have known each of you. I truly appreciate your assistance, advice, help, and friendship in general! Thanks so much, my friends!



New Hawaii Beacon Frequencies

Paul Lieb, KH6HME's unexpected death has brought a need to re-evaluate the best use of the KH6HME beacon. Here WB6NOA writes about what makes the beacon signals propagate, what is the future, along with a request from you for your opinion concerning the best frequency management of those beacons.

By Gordon West,* WB6NOA

The unexpected loss of Paul Lieb, KH6HME, a year ago, was a shock to the VHF/UHF weak-signal community. For more than twenty years, Paul's Hawaii beacons at 8200 feet on active volcano Moana Loa blazed tropo paths from the "Big Island" to the West Coast of North America.

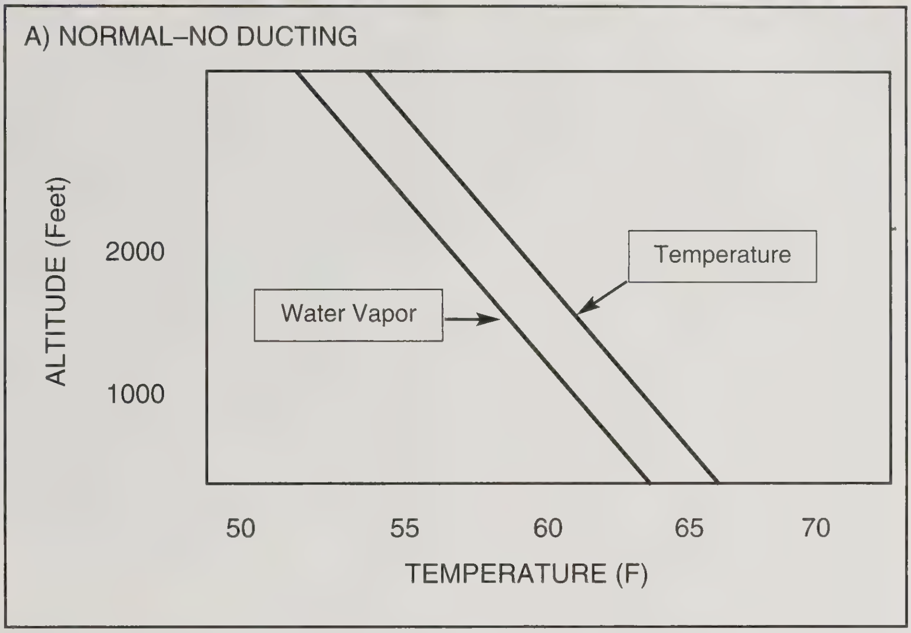
"A group of local Big Island hams and other supporters have pledged to keep Paul's legacy alive," comments Fred Honnold, KH7Y.

"The Big Island hams, members of the California-Pacific Amateur Radio Club, are committed to keeping the beacons operational and continuing Paul's tropo work," adds Fred.

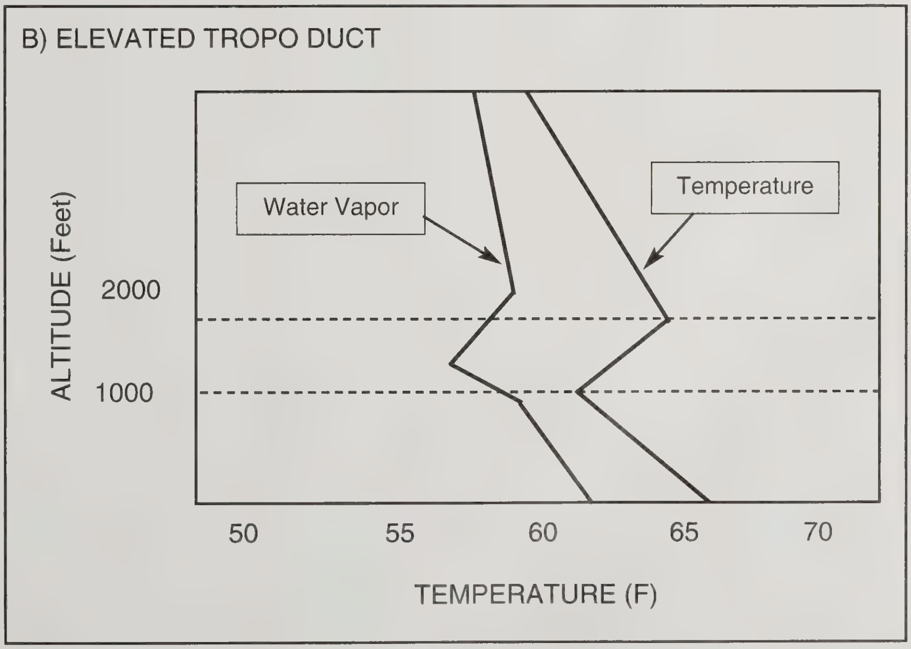
The California-Pacific Amateur Radio Club (P.O. Box 1939, Hilo, Hawaii 96721) has announced the KH6HME callsign has been transferred to the club, thanks to the support of Paul's family. The club will maintain the core beacons on 2 meters, 70 cm, and 23 cm up on the side of the volcano. The 6-meter beacon, near sea level, may also continue. The 6-meter beacon is more often received via short periods of sporadic-*E* propagation than regularly received for days during periods of tropospheric ducting.

Fred Honnold, KH7Y, and the 8200-foot elevation site manager have a long-time acquaintance, both having been involved in commercial broadcasting. The Hawaii beacons will remain in the same tin shed on the side of the mountain volcano, which also houses commercial broadcast transmitters.

"Recently, Dean, KH6B, and I went up to the site and gave it a good looking-over. We are replacing a 50-amp power supply and re-installing a mast holding the 222-MHz and 432-MHz antennas. The 2-meter stacked array is mounted on



Normal rate of air pressure, humidity, and temperature, with increasing altitude.



Warm air inversion, trapping radio waves over 2,500 miles away!

**CQ VHF Features Editor, 2414 College Dr., Costa Mesa, CA 92626*
e-mail: <wb6noa@cq-vhf.com>

a tower leg and is in fine working order," adds Fred.

The original beacon stations sent the CW beacon on 144.170 MHz and the 70-cm signal on 432.075 MHz. However, the club has decided to move both beacon frequencies a little higher up—2 meters, 144.275 to 144.300 MHz; and 70 cm, 432.300 to 432.400 MHz.

Numerous West Coast weak-signal operators were asked to send suggestions as to where the KH6HME beacons might transmit in the beacon sub-band. There were plenty of discussions about existing West Coast beacons, about analog TV station spurs that might disrupt clean reception, and the likelihood of home electronics spurs that seem to appear every 100 kHz on the 2-meter and 70-cm bands.

Now that USA television stations have gone digital, their annoying spurs have disappeared in major metropolitan areas such as San Diego, Los Angeles, and San Francisco. However, almost all weak-signal operators agreed that avoiding even 100 kHz might help minimize numerous spurs coming out from home electronics.

Taking in to account existing West Coast beacons, here are the presently agreed upon frequencies for the new KH6HME beacon band operation:

2 meters: 144.276 MHz
70 cm: 432.310 MHz

"As in the past, KH6HME beacons will be operational on other bands, too," adds Fred, KH7Y. "This includes *all* ham bands up through 10 GHz, and beyond!" says Fred.

It is always a delicate balancing act when one tries to accommodate multiple modes within the same ham bands at the same tower location. Great arguments can be made for the value of FM repeater communications from a high-site location, especially in times of an emergency. Yet ham radio is the perfect proving ground for long-haul VHF/UHF and microwave studies, and the path between Hawaii and the west coast of mainland USA goes back over 50 years!

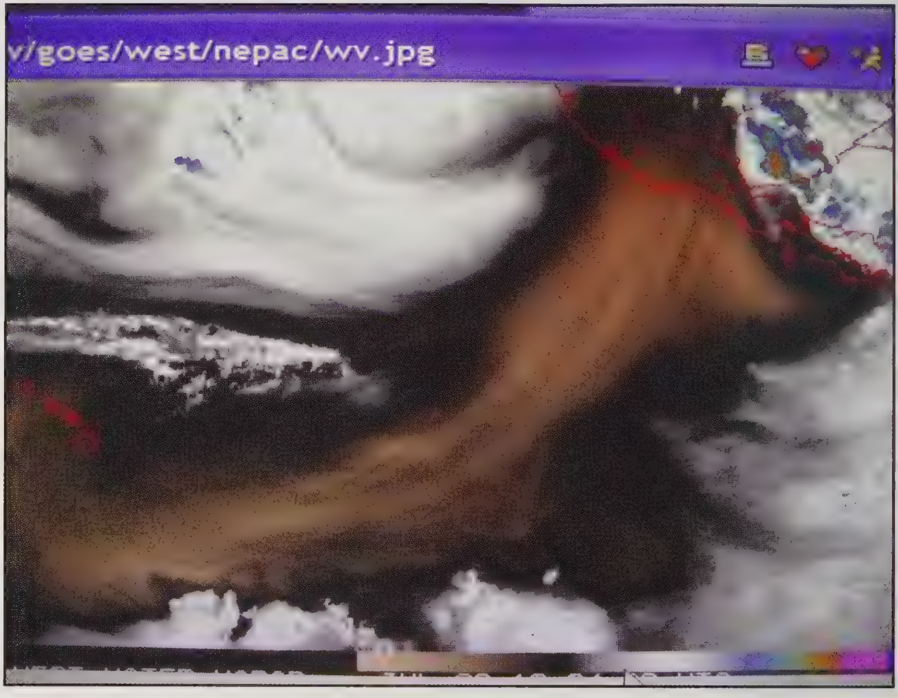
The weak-signal path can sometimes be *so* strong that even the same-site FM repeater can be heard clearly from San Diego to San Francisco!

The Propagation Trigger

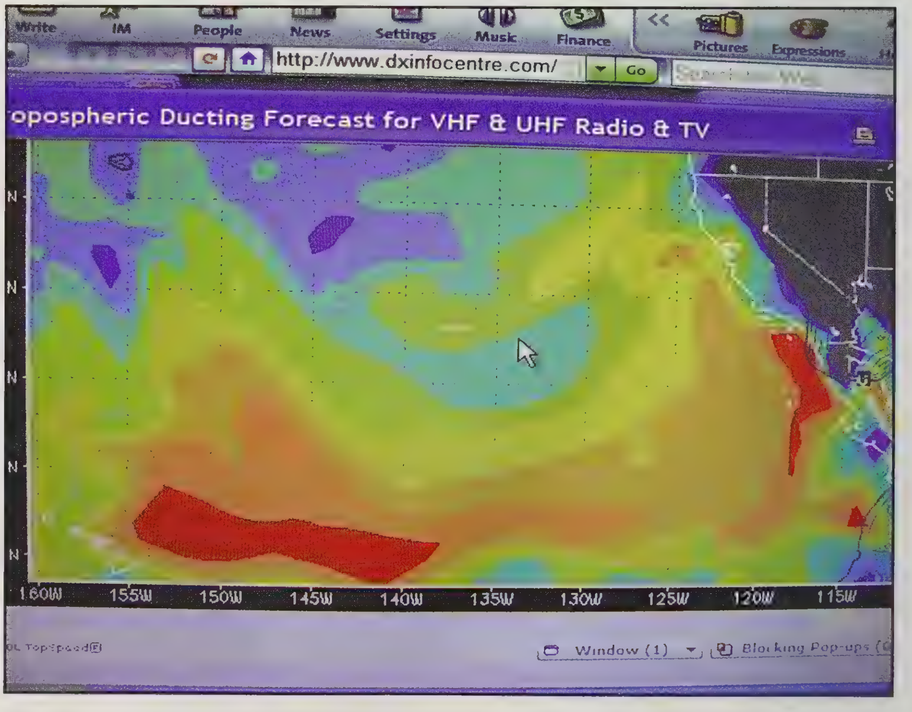
The "trigger" that pulls open the 2500-mile path between Hawaii and the West Coast is the every-July stationary Pacific high. Subsidence out of the high-pressure cell straddling this 2500-mile path causes air to become layered and compressed near the ocean during periods of hurricane moisture coming up from the south. As these air masses begin to stratify, an inversion layer starts to form at the top of the blanket of low coastal clouds.

"When it is drizzling down here in Hilo, in July there is a good chance we will have a band opening via tropo ducting," says Fred.

My numerous pages of atmospheric notes from Paul Lieb, KH6HME, confirm this phenomenon. As soon as he drove up and out of the cool sea air below, Paul



Undisturbed warm air between the mainland US and Hawaii, leading to a strong tropo duct.



The Hepburn daily chart (http:// http://www.dxinfocentre.com) shows a strong opening most of the way to Hawaii and the US mainland.

would indicate a 10-degree rise in the air temperature just above the 8000-foot cloud tops hugging the side of the volcano.

On the mainland West Coast, the cool low clouds (called "California June Gloom") might only extend 500 feet in elevation, with that same sharp increase in air temperature just above the smooth cloud layer extending out to sea as far as your eyes could see. This would be the other end of the tropo duct "wave guide."

If the 2500-mile tropo duct, of relatively undisturbed air below, was well formed, amateur radio transmissions between 144 and 432 MHz would travel the distance within this broad inversion layer.

However, during periods of intense stratification of weather layers from a slow-moving hurricane pushing up from Mexico (common in July) the tropo duct could develop multiple sharp boundaries of air temperatures, increasing with altitude air pressure along with an increase in vapor content. *Normally*, vapor content, air pressure, and air temperature *decrease* with altitude. However, in July between California and Hawaii the inversion layer may create some very interesting patterns.

West Coast hams were quick to learn that driving to a 5000-foot coastal peak literally could put them above and out of contact with the beacons. Chip Angle, N6CA, "the master of microwave tropo," has a favorite spot just above the low coastal clouds, no more than 500 feet above sea water. Chip and Paul have confirmed contacts on the 5-GHz band, and we all think that 10 GHz is possible if the conditions are just right.

Most ham tropo beacons are horizontal, yet weather and public-safety signals are almost always vertical. Also, ham repeaters are vertical, as are APRS stations. Polarization will *not* rotate within a duct.

Amateur radio operators operating SSB/CW, exclusively use horizontal polarization. Therefore, mobile amateur stations with vertically polarized whips are out of luck trying to work SSB, but are *in luck* working several vertically polarized Hawaii repeater stations over the 2500-mile path. In fact, here in southern California, a repeater on Catalina Island, 26 miles offshore and high atop a peak, regularly gets calls from vertically polarized Hawaiian hams driving up to mountaintops!

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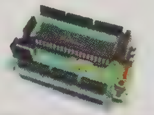

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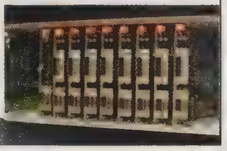

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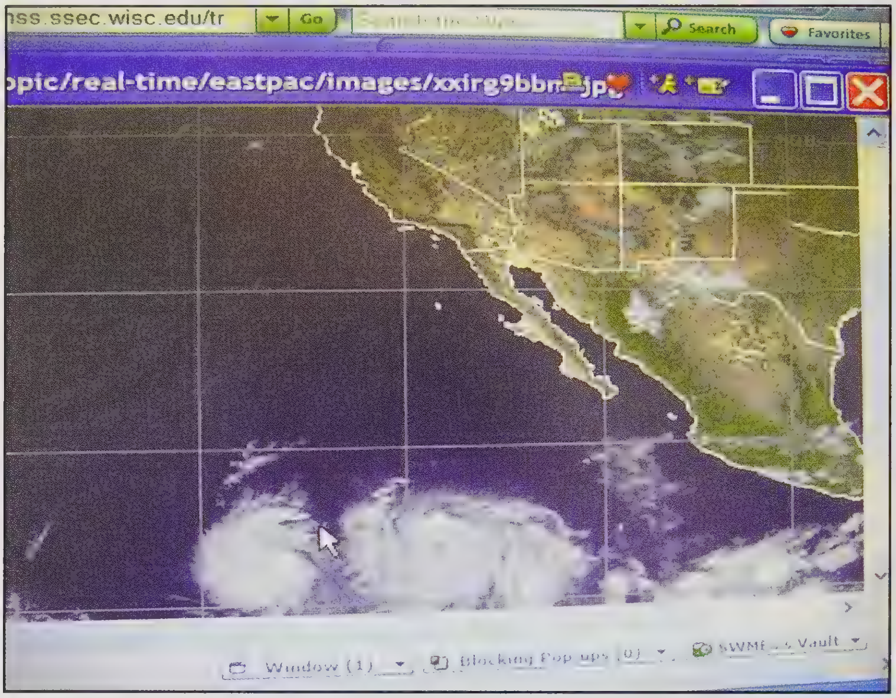
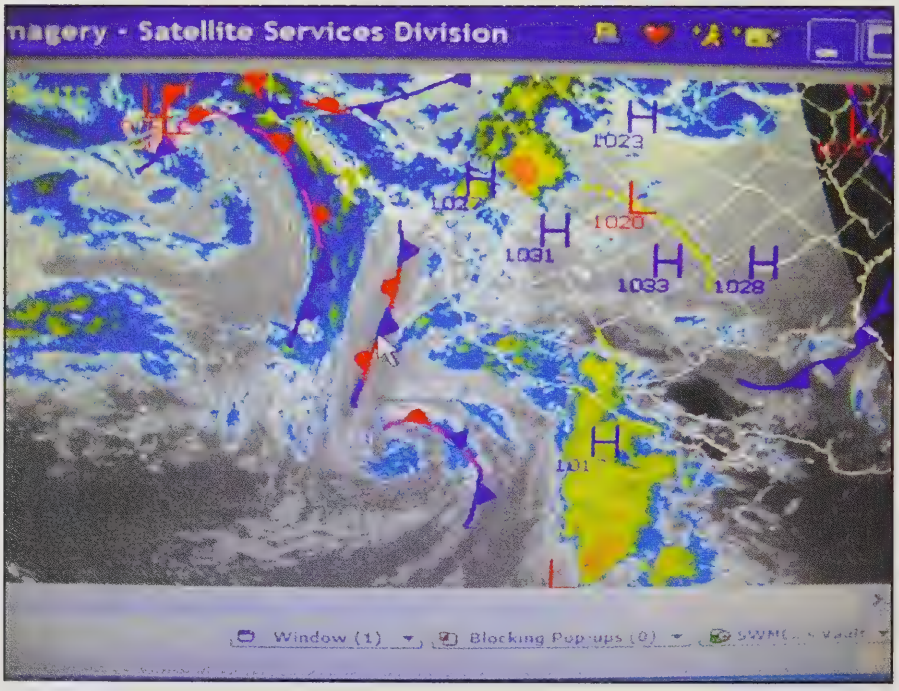
plished by using *no* squelch on SSB. Most multimode squelch circuits have a "trigger" effect that takes many microvolts of signal to briefly open the squelch. Unless your multimode 2-meter or 70-cm receiver has an *extremely slow* AGC, the beacon single dit or dah might escape your attention.

Therefore, monitor with open squelch and constant background noise, which is *not* a great idea if your family is home. However, there is an easy solution. If your multimode transceiver has Digital Signal Processing in the IF, then go for maximum DSP, crank the volume halfway up, and without the beacon present, watch DSP noise subtraction at its best.



When hurricanes spawn to the south and move north, they usually trigger long-range tropo ducting as the atmosphere begins to form distinct layers.



National Oceanic Atmospheric Agency color images help identify favorable tropo conditions between the US mainland and Hawaii.

In about five seconds, all you might hear coming out of your speaker is a little gurgling. Now turn the volume down a bit and stand by for the beacon! When the beacon comes in, at a fraction of a microvolt, it instantly will punch through the DSP noise subtraction mask, and you will hear the signal all over the house!

If you have an older multimode 2-meter/70-cm rig *without* DSP, then you are still in luck with an add-on DSP audio filter speaker. The following units are suggestions: Timewave (http://www.timewave.com/amprods.html); MFJ Enterprises (http://www.mfjenterprises.com; search DSP filters); Hear It (a GAP product; http://www.gapantenna.com/hearit.htm); West Mountain Radio Audio Ware (http://www.westmountainradio.com/content.php?page=dsp-speakers); and SGC (ADSP; http://sgcworld.com/store/page8.html).

Add 12 VDC to the DSP speaker system (less than a quarter amp in idle), crank the DSP noise subtraction to near max, and listen to noise of background SSB/CW white noise disappear into a low gurgle. Now adjust your transceiver's volume down a bit, increase the volume on your DSP add-on speaker, and, when a *trace* of the beacon gets into your horizontally polarized antenna system, it will be *heard*!

Tropo Propagation

Summertime tropo paths are not only the ones between California and Hawaii. Texas to Florida is common. Florida to Nova Scotia, with a hurricane to the south is common. Over land, Chicago to Alabama is an occasional summertime occurrence.

During periods of hot, windless weather, tune around on the seven weather channels near 162.550 MHz and don't be surprised if you pick up weather stations 200 and 300 miles away. This is a mini-tropo opening. Keep listening, as it could extend up to 800 miles a few hours later.

The tropo ducts usually open in the late afternoon and go well into the evening. These are the mechanics of atmospheric heating and stratification. A high-pressure system overhead is usually a good indication to start listening for VHF/UHF DX. Any hurricane coming up from the south is another prelude to tropo ducting.

Finally, 2 meters will open first, and then look to UHF when conditions get great on 2. If they really get cooking, know that the higher bands may soon get into that magical waveguide called a *temperature-inversion, tropospheric duct*.

Tributes

To Paul Lieb, KH6HME, a gentle, soft-spoken giant in tropo ducting, thanks for adding a new dimension of weak-signal excitement to our ham radio bands. We also acknowledge the tropo work conducted by net control operator David Peters, KI6FF, recently a SK. Long live their experiments with tropo science!

QSO Frequency Decision

Still to be decided is the actual QSO frequency to use when the Hawaii stations get to the beacon, shut it down, and begin to operate the US mainland. Paul Lieb, KH6HME, would stay on the beacon frequency and make QSOs there, as everyone was listening! However, it has been suggested that QSOs might take place OFF the beacon frequency.

Changing from beacon frequency to QSO working frequency could leave some Mainland stations thinking the beacon is just in a fade, not realizing the beacon was shut off, and the QSOs are going on at another spot on the radio dial!

Do you have an opinion? Please send me an e-mail at: <wb6noa@cq-vhf.com>.

Mobile stations along the West Coast don't need much elevation to access the tropo duct to Hawaii. A clear shot to the west and the ocean is all that is needed!

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KickSat
Bringing Space to the Masses

Have you ever wished to be a part of the launch of a satellite? Here KD2BHC describes his project, which can make your wish come true, along with a request for your participation as a possible ground station.

By Zac Manchester,* KD2BHC

Who hasn't dreamed of launching their own satellite? The opportunities afforded to scientists, hobbyists, and students by cheap and regular access to space could open up new areas of scientific research and enhance participation in science, technology, engineering, and math (STEM) education. The KickSat project, begun at Cornell in 2011, is trying to put space within reach of everyone by dramatically lowering the cost and technical expertise required to build and fly a satellite. This article will provide an overview of KickSat and its communication system, including information for setting up an amateur ground station.

The Sprite Spacecraft

CubeSats have received a lot of well-deserved attention in the last few years. They've helped greatly expand the opportunities for students and hams to participate in space. Unfortunately, however, the barriers to entry remain high. The cost of building and launching a CubeSat is typically measured in hundreds of thousands of dollars and its development, integration, and testing usually requires a team with broad engineering expertise.

Thanks to rapid advances made in the semiconductor industry, it is now possible to integrate most of the features of a traditional spacecraft into a chip-scale device. At Cornell, we've leveraged the sort of tiny, low-cost, low-power integrated circuits used in modern consumer electronics to build the Sprite, an example of a new category of spacecraft known as a "ChipSat" (figure 1) or "femtosatellite." The Sprite includes solar cells, a Texas Instruments MSP430 microcontroller, a 70-centimeter band transceiver, and several sensors on a printed circuit board measuring 3.5 by 3.5 centimeters and is, to the author's best knowledge, the world's smallest purpose-built spacecraft.

The Sprite is intended as a general-purpose platform for small experiments, serving as host to any of the numerous chip-scale

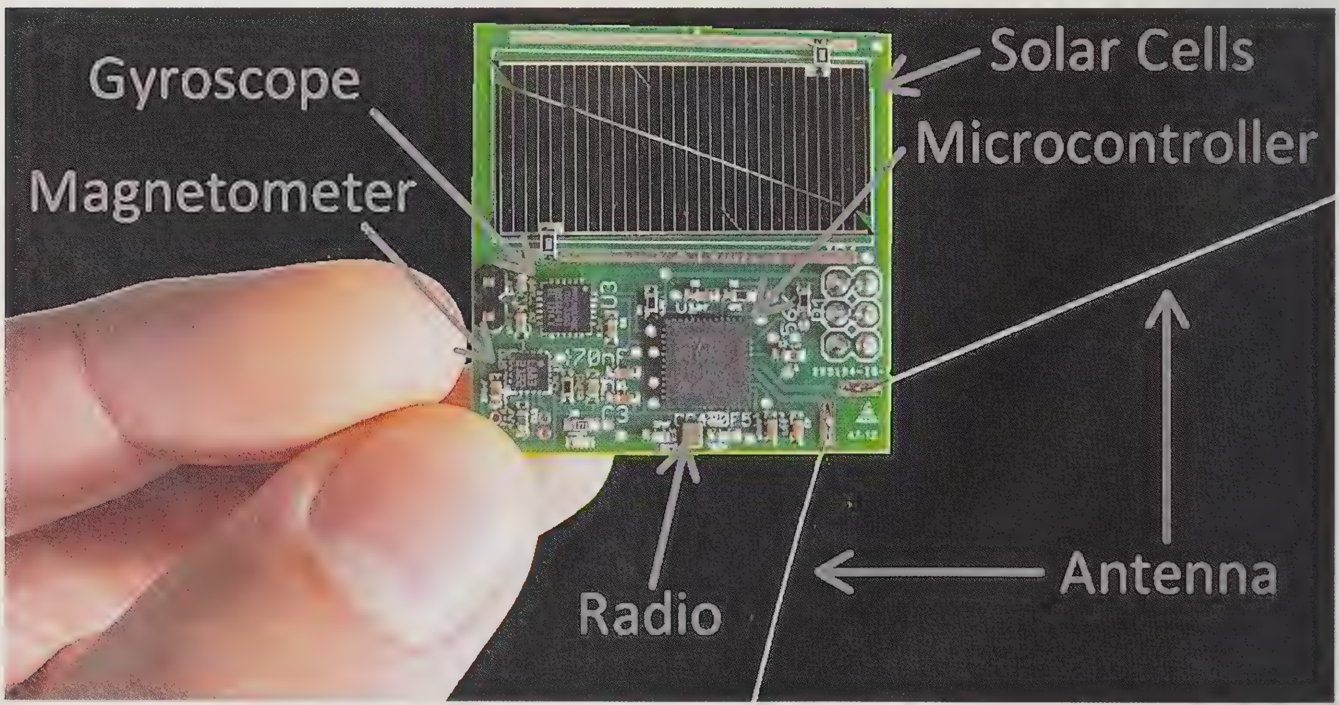

Figure 1. Sprite ChipSat

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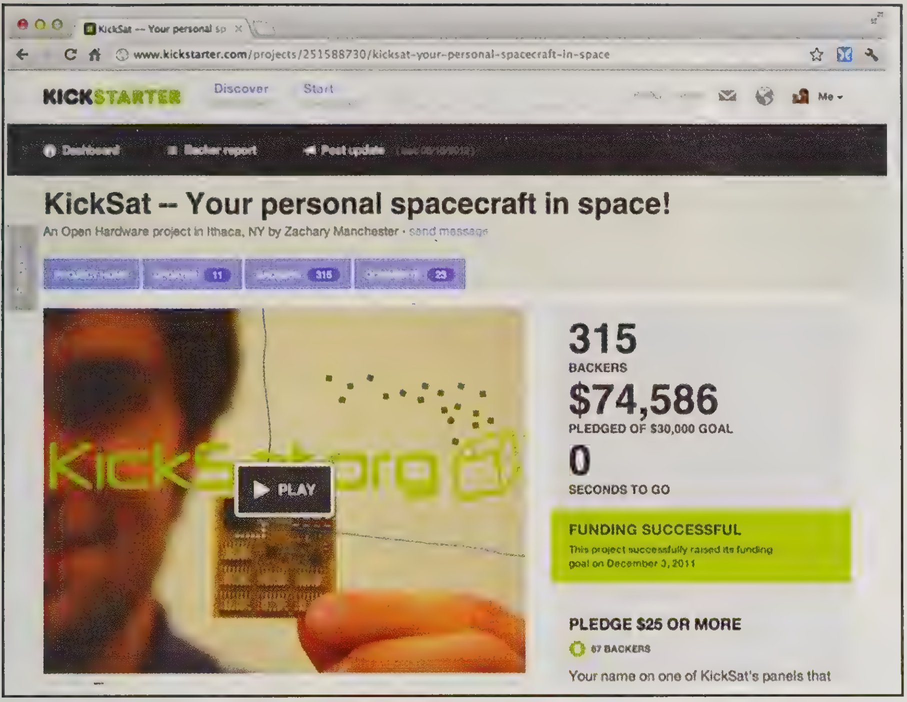
*e-mail: <zrm3@cornell.edu>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315
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This project successfully raised its funding goal on December 3, 2011

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Your name on one of KickSat's panels that

Figure 2. KickSat on Kickstarter

sensors now commercially available. In the near future it will be possible for a student or hobbyist with basic electronics skills to choose a sensor or two, write some microcontroller code, and put together a working satellite with a few hours' work. By shrinking the spacecraft and launching many together, we can realistically achieve per-Sprite launch costs of $1,000 or less at current prices.

KickSat

The KickSat mission is a complete end-to-end demonstration of the Sprite, from launch and deployment to communication with ground stations and tracking. It has been made possible through the generous support of over 300 individual backers on the crowd-funding website Kickstarter (figure 2). Over $74,000 was contributed in exchange for rewards such as having a name printed on a solar panel, receiving a souvenir Sprite, or getting to program the flight code on a Sprite.

Kicksat's launch has been awarded through NASA's Educational Launch of Nanosatellites (ELaNa) program, which places university-built CubeSats as secondary payloads on NASA missions. KickSat is currently manifested on CRS-3, a Space-X Falcon 9 set to launch in late 2013. CRS-3's primary mission is to bring supplies to the International Space Station, so KickSat will be placed in roughly the same orbit as the ISS—a 325-km altitude circular orbit with an inclination of 51.5°.

KickSat itself is a 3U CubeSat (figure 3) consisting of a 1U bus and 2U Sprite deployer. The bus is being built using a combination of commercial-off-the-shelf (COTS) CubeSat hardware and Cornell-built hardware to provide standard power, communication, and command and data handling functions. The deployer will house approximately 150 Sprites inside a spring-loaded mechanism actuated by a nichrome burn wire. A command from Cornell's ground station will trigger the burn wire, releasing the Sprites as free-flying spacecraft.

After deployment, the Sprites will remain in orbit for a few weeks before re-entering and burning up in the Earth's atmosphere. During that time, they will collect sensor measurements, perform calculations and, most importantly, communicate with amateur ground stations worldwide (figure 4). The following sections will provide some technical background on the Sprite's communication system and the hardware and software required to set up a receiver. More information on Kicksat and updates on the project's status are available online at kicksat.net.

Sprite Communication Background

One of the most difficult engineering challenges associated with the KickSat

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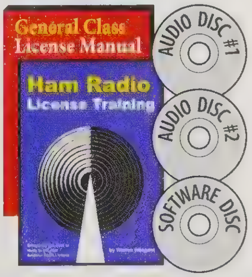


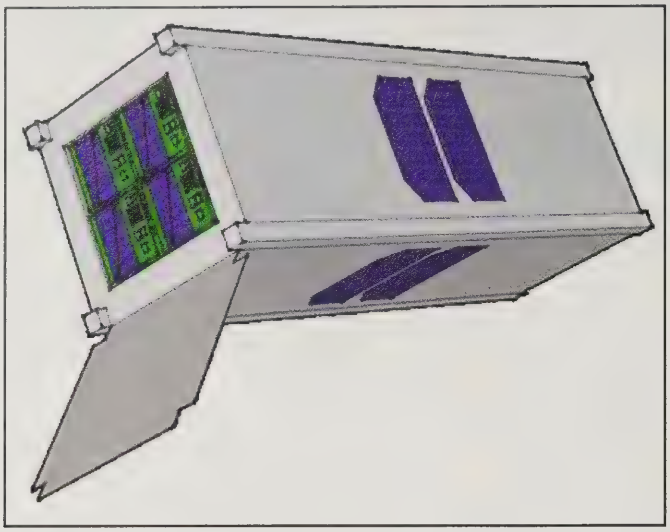


Figure 3. KickSat 3U CubeSat

project is closing the communication link from orbiting Sprites to Earth stations. The Sprite's transmitter is limited to about 10 milliwatts of power. Additionally, a lack of attitude control (the ability to point or reorient the spacecraft) means a low-gain antenna with an omnidirectional gain pattern is required. Lastly, we need an efficient way for all of the Sprites on a given mission to share limited bandwidth. Closing link over several hundred kilometers with all of these constraints may, at first glance, seem impossible, but with some signal processing, it turns out to be quite doable with relatively cheap hardware. This section will provide a conceptual overview of the techniques used in the Sprite receiver for the non-expert.

Let's start with some basic link budget calculations. We'll follow the link from end to end, working in decibels, to estimate the signal to noise ratio (SNR) at the receiver. A Sprite transmits with a power of 10 mW or 10 dBm. The Sprite's V-dipole antenna is approximately isotropic with a gain of about 0 dB. To account for downrange distance and allow for some margin on top of the Sprite's 325-km orbital altitude, we'll baseline a distance of 500 kilometers. The Friis equation gives us a free space path loss of:

$$20 \log \left(\frac{\lambda}{4\pi r}\right) = 20 \log \left(\frac{.7}{4\pi \cdot 5 \cdot 10^5}\right) \approx -139 \text{ dB}$$

We'll assume our receiver antenna has about 7 dB of gain, consistent with a small handheld Yagi. Adding up these values, we find that our received power should be in the neighborhood of −122 dBm.

The next thing we need to calculate is the noise power in the receiver. There are two main components to worry about—naturally present thermal noise and the noise introduced by the receiver components themselves. Thermal noise is given by 10 log ($K_B T B$), where K_B is Boltzmann's constant, T is temperature in Kelvin (assumed to be about 150 K for space-viewing applications), and B is bandwidth in Hertz. Plugging in the values for our particular case, we get the following:

$$-177 + 10 \log (64 \cdot 10^3) \approx -129 \text{ dBm}$$

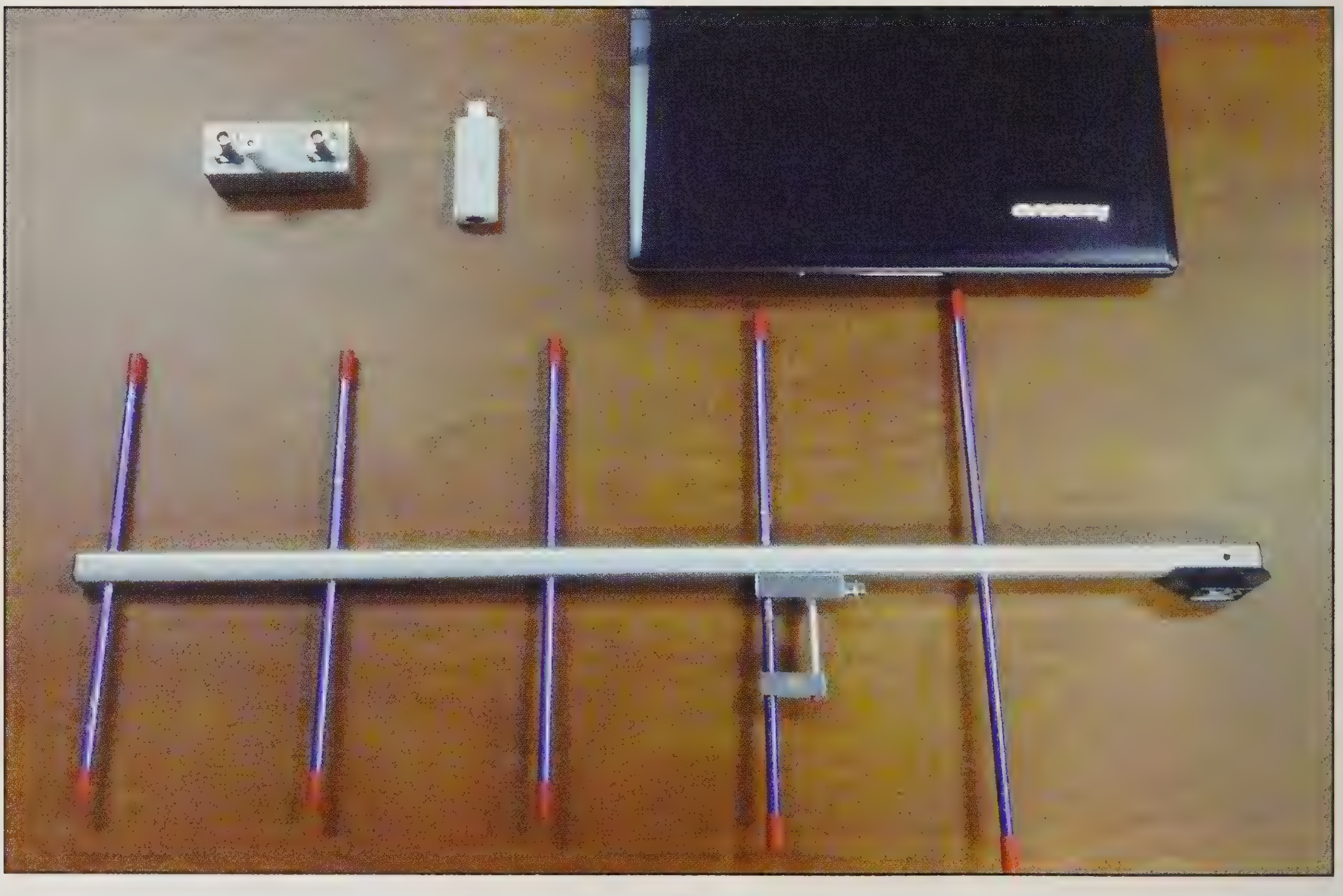


Figure 4. Ground station hardware

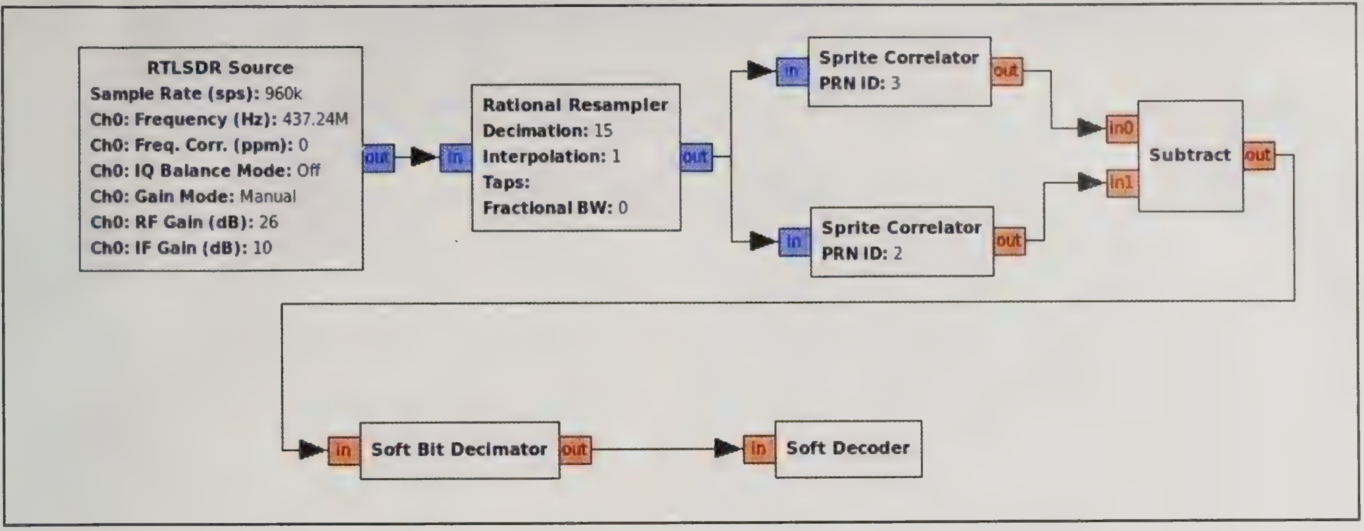
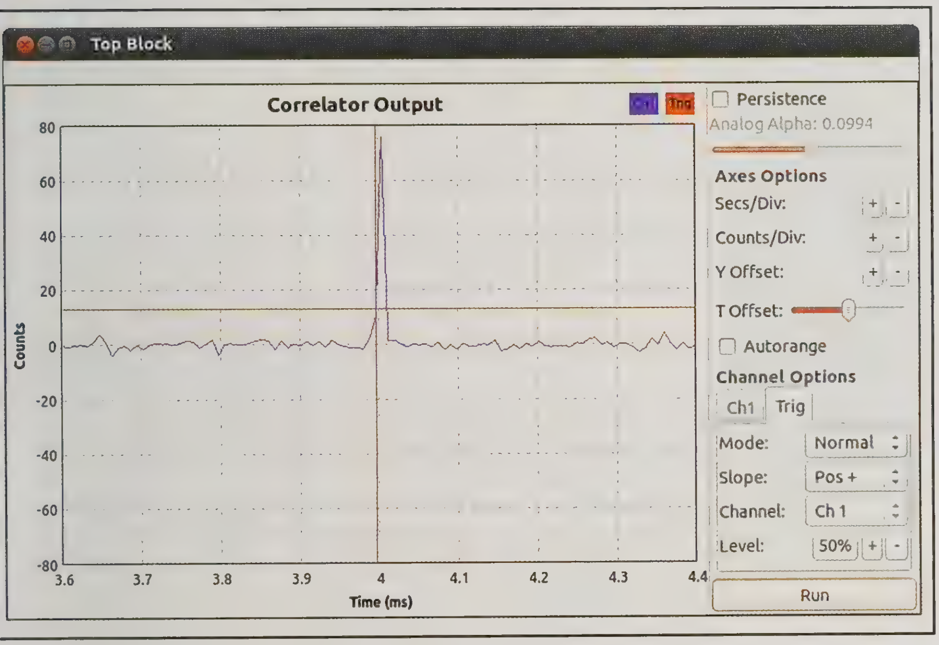

RTLSDR Source
Sample Rate (sps): 960k
Ch0: Frequency (Hz): 437.24M
Ch0: Freq. Corr. (ppm): 0
Ch0: IQ Balance Mode: Off
Ch0: Gain Mode: Manual
Ch0: RF Gain (dB): 26
Ch0: IF Gain (dB): 10
out
in
Rational Resampler
Decimation: 15
Interpolation: 1
Taps:
Fractional BW: 0
out
in
Sprite Correlator
PRN ID: 3
out
in
Sprite Correlator
PRN ID: 2
out
in0
in1
Subtract
out
in
Soft Bit Decimator
out
in
Soft Decoder

Figure 5. Receiver block diagram


Top Block
Correlator Output
Ch1
Trig
80
60
40
20
0
-20
-40
-60
-80
Counts
3.6
3.7
3.8
3.9
4
4.1
4.2
4.3
4.4
Time (ms)
Axes Options
Secs/Div:
Counts/Div:
Y Offset:
T Offset:
+
-
Channel Options
Ch1
Trig
Run

☐ Persistence

Analog Alpha: 0.0994

☐ Autorange

Mode: Normal

Slope: Pos +

Channel: Ch 1

Level: 50%

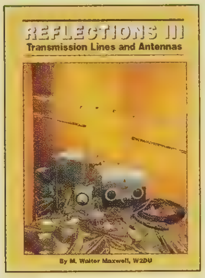
Figure 6. Correlator output

The receiver's self-induced noise, expressed in dB as noise figure, has to be measured. For our purposes, we'll assume a noise figure of 9 dB, which is representative of what can be achieved with low-cost hardware. Adding these together, we get a noise power of about –120 dBm.

If we subtract the results of our two previous calculations, we find that our SNR is around –2 dB, the negative sign indicating that we have more noise than signal in the receiver. While this situation might more typically be resolved by increasing transmitter power or using higher-gain antennas, neither of those are viable options in our case. Instead, we'll make use of a trick used for decades by radar systems and the Global Positioning System (GPS) known as matched filtering.

For those who haven't studied signal processing, the basic idea behind matched filtering is to substitute each data bit with a long, specially chosen string of bits known as a pseudo-random number (PRN) code that is agreed upon by the transmitter and receiver beforehand. Rather than trying to lock onto the carrier or look for individual bits, the receiver looks for the PRN code by calculating a statistical correlation against the incoming signal. If the code is present, the correlation will be high, even in the presence of substantial noise, while if no code is present, the correlation will be low. The technique essentially allows the energy in the entire PRN code to be integrated up and treated as a single bit, providing a gain equal to the PRN length.

For the KickSat mission, we're using PRN codes that are 640 bits long, providing a "code gain" of about 28 dB. Adding this to our SNR puts us at a very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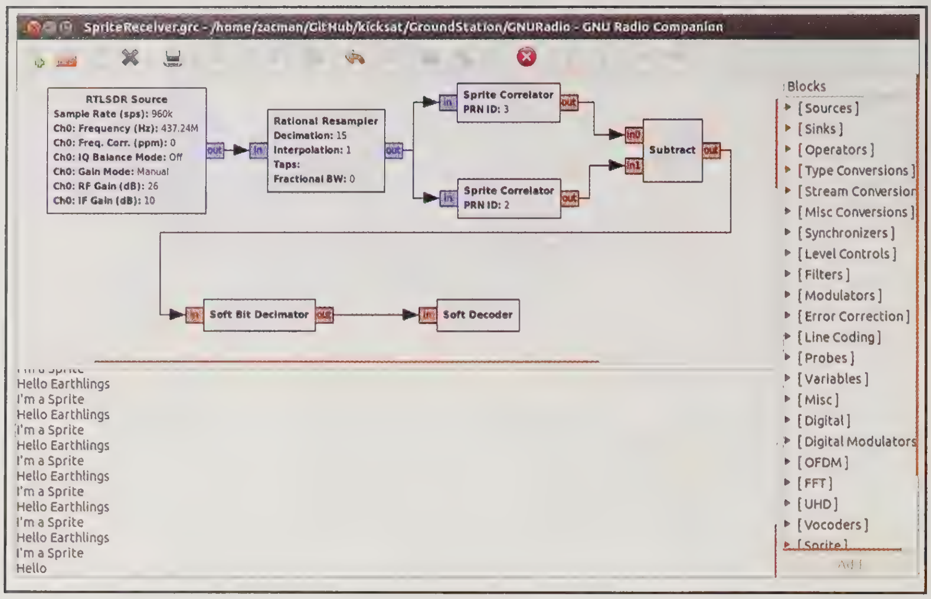

SpriteReceiver.grc - /home/zacman/GitHub/kicksat/GroundStation/GNURadio - GNU Radio Companion

RTLSDR Source
Sample Rate (sps): 960k
Ch0: Frequency (Hz): 437.24M
Ch0: Freq. Corr. (ppm): 0
Ch0: IQ Balance Mode: Off
Ch0: Gain Mode: Manual
Ch0: RF Gain (dB): 26
Ch0: IF Gain (dB): 10

Rational Resampler
Decimation: 15
Interpolation: 1
Taps:
Fractional BW: 0

Sprite Correlator
PRN ID: 3

Sprite Correlator
PRN ID: 2

```
Hello Earthlings
I'm a Sprite
Hello Earthlings
I'm a Sprite
Hello Earthlings
I'm a Sprite
Hello Earthlings
I'm a Sprite
Hello Earthlings
I'm a Sprite
Hello Earthlings
I'm a Sprite
Hello
```

Figure 7: Receiver output

respectable +26 dB. Keep in mind, however, that our data rate is now also lower by a factor of 640, so there's no free lunch. We've simply managed to trade data rate for gain.

Matched filtering helps us close our link, but it also helps us in another way. By assigning different PRN codes to each Sprite, we can implement code-division multiple access (CDMA), with which you may be familiar from the cellular telephone standard. Rather than assigning each Sprite its own frequency, they all can share one frequency and the receiver can "tune" to a particular Sprite by looking for its unique PRN code. This has several advantages, including reduced use of spectrum, simplified licensing, and the ability to record the signals from all the Sprites in a pass with one receiver.

The last piece of theoretical background we need is forward error correction (FEC). FEC is widely used in modern digital communication because it allows a receiver to correct noise-induced errors in a message without having to ask for a retransmission. The idea is to pad the message with extra bits, known as parity check bits, based on some mathematical rule. In our case, a linear block code is used where a block of data is treated as a binary vector and encoded by simple matrix multiplication.

To encode a byte, the Sprite multiplies the corresponding 8-bit vector by an 8-by-16-bit matrix, known as the generator matrix of our code, to produce a 16-bit code word. The receiver can take advantage of the redundant bits in the code word and their mathematical relationship to the message bits to reproduce the original message byte, even if errors have been introduced in transmission. For those familiar with coding theory, our code is a (16,8,5) block code, and therefore can detect and correct up to 2 bit flips or 5 bit erasures.

Sprite Receiver

With the goal of allowing as many people as possible to participate in the KickSat project, we've assembled and tested a reference design for a low-cost and portable KickSat receiving station. The hardware consists of a hand-held Yagi antenna, an LNA, a DVB-T USB dongle, and a PC running the GNURadio software. The total hardware cost, not including the PC, is around $200. Full instructions for assembling a ground station will be available on the KickSat project wiki, accessible at <http://www.kicksat.net>.

Because of the signal-processing requirements inherent in our receiver design, a software defined radio (SDR) receiver is being used. The DVB-T dongle functions as a low-cost front end and analog-to-digital converter, bringing the raw baseband signal into the PC. From there, our receiver is written in C++ as a set of blocks for the GNURadio software framework. The block diagram in figure 5 shows the signal flow in the receiver.

Starting from the DVB-T dongle input on the left, the signal is decimated (low-pass filtered and down-sampled) to one sample per PRN chip, which is 64 kHz in our current implementation. From there, it passes through two PRN correlators, each of which performs matched filtering against a different PRN code. Figure 6 shows the output of a correlator in which the spike corresponding to a PRN code is clearly visible.

Each Sprite is assigned two PRNs—one corresponding to a zero bit and one corresponding to a one bit. The correlator outputs are subtracted, giving a zero-mean signal where a one corresponds to a positive spike and a zero corresponds to a negative spike. The signal is then down-sampled again, this time to 200 Hz, by the Soft Bit Decimator block, before passing into the decoder.

The Sprite decoder is a maximum-likelihood soft decoder. It takes a group of spikes from the correlators and determines the byte to which they most likely correspond, taking into account the parity bits. The best match is then printed to the console. Figure 7 shows a screenshot of a running receiver with decoder output at the bottom of the window.

The Sprite software receiver can run in real time on relatively recent PC hardware. It can also be used in a batch mode where data is recorded during a pass and later fed through the receiver. Both scenarios have been tested outdoors with Sprites and receiver separated by 25 miles and an additional 23 dB of attenuation inserted after the receiver antenna, roughly corresponding to the link conditions between LEO (Low Earth Orbit) and Earth stations anticipated for the KickSat mission.

Conclusion

KickSat represents a new way for people across the world to participate directly in spaceflight. With very modest hardware, amateurs can receive signals from Sprites in LEO during the KickSat mission. All of the design files and code for the Sprite and its software receiver are open source and available online for anyone to build their own or use as a starting point for new designs.

Acknowledgements

The author would like to thank the many people who have supported KickSat financially through Kickstarter, as well as Andy Filo for many technical contributions.

Building The Slap Shot

A Hockey Stick Satellite Antenna

Games played with curved sticks and a ball can be found in the history of many cultures —especially Canadians and their love of hockey. Here VE4CWF takes hold of that craze to develop a curved-stick antenna to be aimed at a ball in space,

By Christopher Friesen,* VE4CWF

VE4CWF working SO-50 on a cold night.

The year 2013 began with the National Hockey League (NHL) in a labor lockout, and while most Canadians were lamenting the loss of their favorite winter sport, I was not. I was busy building a portable antenna for satellite operation, one that would shoot the five watts from my handheld transceiver into the five-hole of SO-50. To score that goal I needed to build an antenna that was lightweight and ergonomic and able to stand up to the extremely cold temperatures of my northern climate. The "Slap Shot" was the result—a portable, cross-polarized VHF/UHF antenna designed specifically for working Low Earth Orbit (LEO) satellites, using a plastic floor-hockey stick for the boom.

Design Parameters

The antenna itself is not original. I used the "Cheap Yagi" dimensions found on the website of Kent Britain, WA5VJB (www.wa5vjb.com). His design and construction methods are readily available as a PDF download. I chose to build the 2-meter portion with three elements and the 70-cm portion with five elements. Britain's design uses $^1/2$ folded dipoles for the driven elements. This design is easy to construct and easy to feed with coax. The shape of the driven element is shown in figure 1 and the element lengths and spacing I used are shown in Table 1. Other than the hockey-stick boom, the Slap Shot is a junk-box antenna. For my prototype, the elements and mounting hardware were all derived from salvaged parts.

Why a Hockey Stick?

Floor-hockey sticks have several advantages for antenna construction. They are made from rectangular, tubular plastic which provides nice flat surfaces for mounting antenna elements. The plastic provides an insulated lightweight boom, accepts wood screws without requiring predrilling, and is workable with simple hand tools. Cross-sectional dimensions of

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*20 Kimberly Bay, Steinbach, MB
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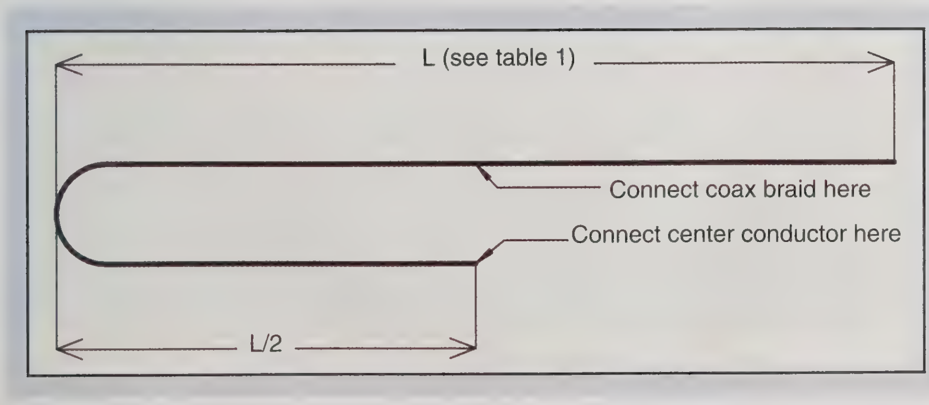

Figure 1. Cross section of a $^1/2$ folded dipole driven element.

Element Dimensions

2 meter Dimensions

Element	Reflector	Driven (L)	Director
Length	40.5" (1029 mm)	38.5" (978 mm)	36.5" (927 mm)
Spacing	0.0	8.5" (216 mm)	19.75" (502 mm)

70 cm Dimensions

Element	Reflector	Driven (L)	Director 1	Director 2	Director 3
Length	13.5" (343 mm)	13.0" (330 mm)	12.5" (318 mm)	12.25" (311 mm)	11.75" (298 mm)
Spacing	0.0	2.5" (64 mm)	5.25" (133 mm)	12.0" (305 mm)	18.5" (470 mm)

Table 1. Element length and spacing.

1$^1/_8$" × $^3/_4$" provide the perfect spacing for the folded dipole design and at a price of $5.49, well within the budget of the thriftiest amateur. The blade of the hockey stick provides a convenient point to rest the antenna at the hip, providing a pivot point to rapidly change polarity while supporting the antenna with only one hand.

Construction

1. Build the 70-cm elements.

The 70-cm elements were made using #10 AWG bare copper wire originally used to make decorative garden ornaments. Any stiff wire, rod, or small-diameter tube can be used for these elements provided it is long enough and pliable enough to form the $^1/2$ dipole on the driven element. I used a broomstick to form a 1inch radius in the wire.

2. Build the 2-meter elements.

The 2-meter elements were built using salvaged parts from old TV antennas. Photo A shows the hockey-stick boom laid out next to salvaged elements and mounting hardware, along with my prototype UHF receiving antenna built on a wooden boom. The TV antenna elements were not long enough on their own, so I inserted tubular aluminum, held in place with stainless-steel hose clamps, to provide the correct length and some adjustability. The 2-meter driven element was built from one half of a VHF folded dipole, so there was no need to create a bend in the aluminum. If you are unable to find a similar antenna for use in your project, you can build a gamma-matched driven element, or use brass rods for the 2meter elements.

3. Mark the boom and drill all necessary holes.

The length of the hockey stick will

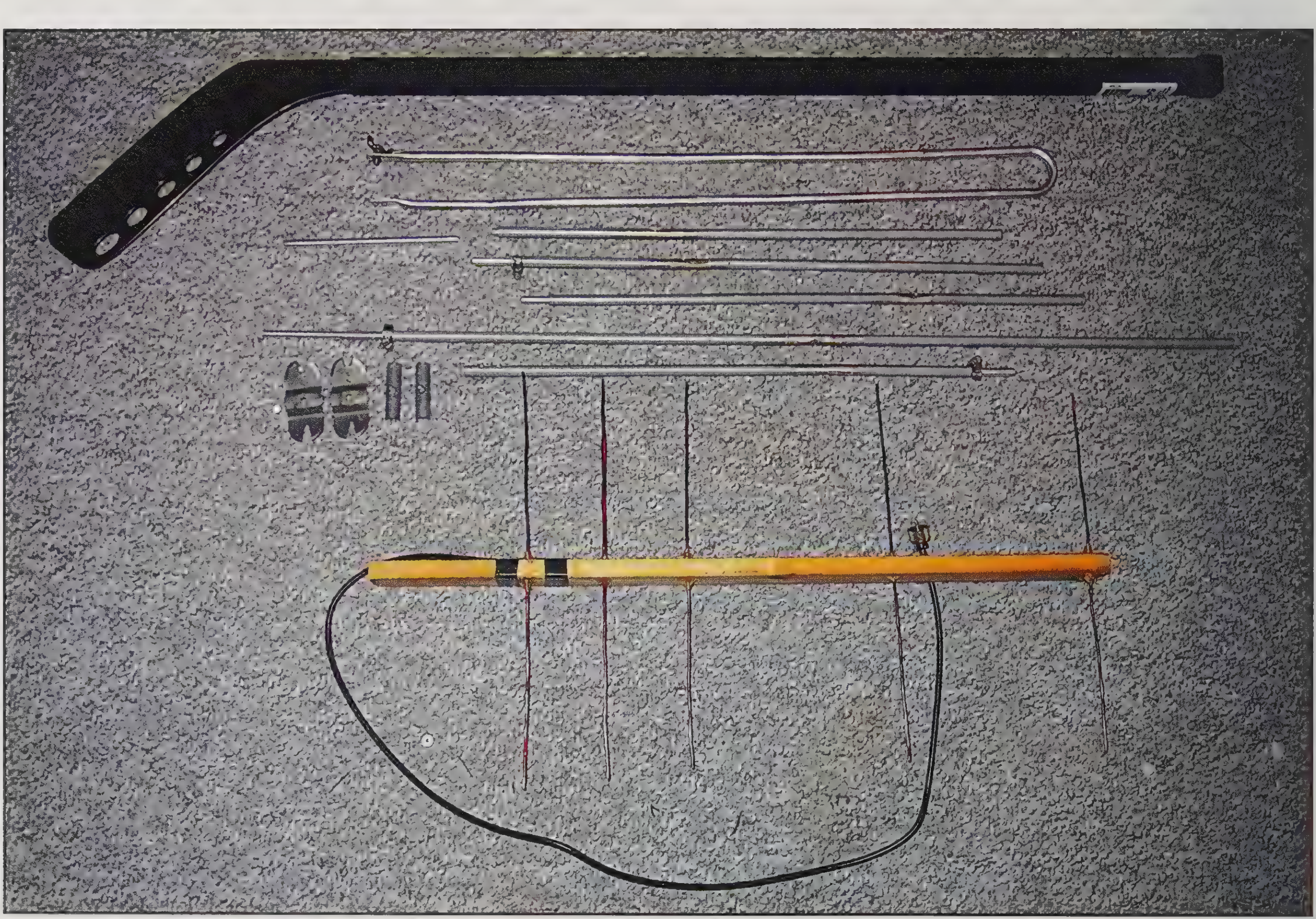

Photo A. Antenna components before assembly.

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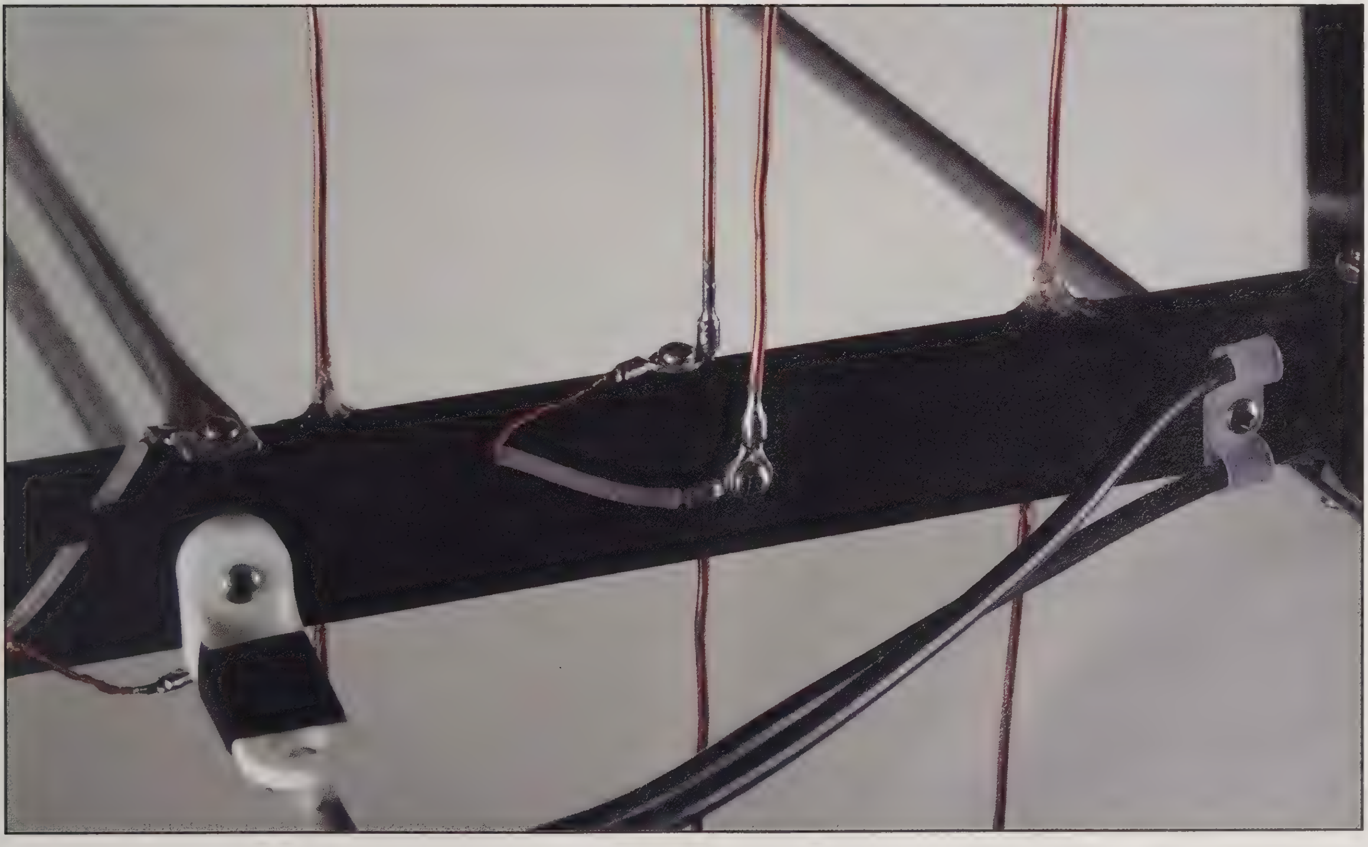

Photo B. 70-cm driven element mounting.

affect the size of the finished antenna, so choose element quantity and spacing with that in mind. Remove the blade from the hockey stick and using the design dimensions, mark it with the locations of the elements. Drill appropriately sized holes; this is best done with a drill press, as it ensures the holes through the boom will be perfectly aligned. Hand drills will also produce acceptable results.

4. Install the 70-cm elements.

The 70-cm elements can be pushed through the holes, centered, and held in place with the adhesive of your choice. I used hot glue, but thermal cycling from bringing the antenna outside in winter, then back inside, causes the elements to expand and contract and break free from the glue. Epoxy might work better, but future builds will employ the method used for securing the 70-cm driven element.

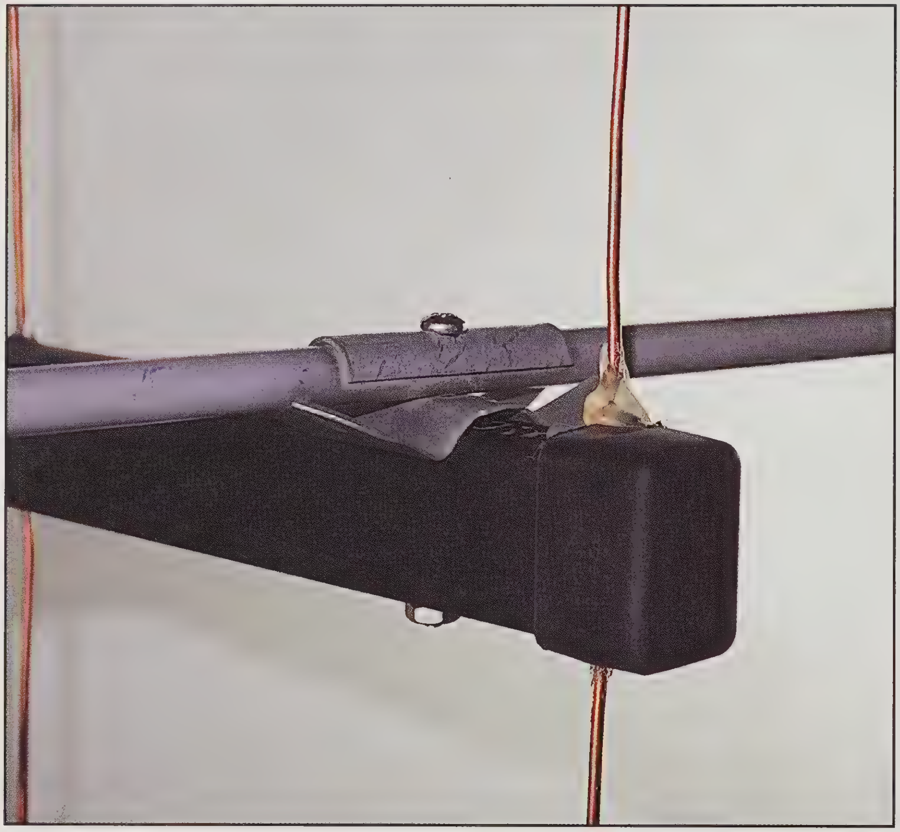

Photo C. Typical 2-meter element mounting.

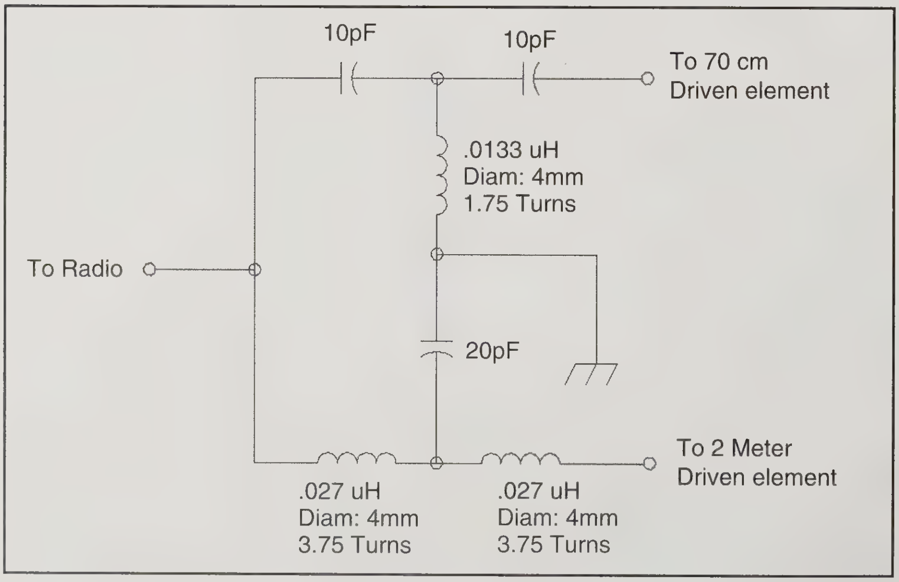

Figure 2. Diplexer circuit diagram.

The driven element is the only element that is not secured with adhesive. I soldered ring terminals onto the end and midpoint, being sure to subtract some length for the width of the boom. Photo B shows the ring-terminal configuration fastened to the finished antenna. The ring terminals provided a place to secure the element to the boom, and they make convenient points to attach the feedline coax. Any future build will use this method to secure the parasitic 70-cm elements as well.

5. Install the 2-meter elements.

The 2-meter reflector and director used the mounting hardware from the original TV antenna and a bolt through the boom as shown in photo C. I did not have a third bracket from the old TV antenna and running a bolt through the boom would have shorted the driven element to itself, so it is attached with separate, short wood screws at the top and bottom. Both locations in the element were pre-drilled with clearance holes and I used a vice to flatten the tubular aluminum to provide flat mounting surfaces. Once constructed, I found the 2-meter driven element did not remain square to the boom, so I added a plastic angle bracket to the boom and used electrical tape to secure the element to it.

Feeding the Antenna

1. Coax feed-point connection.

To feed the antenna, simply attach coax to the center of the driven element and the end of the $^1/2$ folded dipole as shown in photo B. Note that the braid of the coax is connected to the center of the driven element and the center conductor is connected to the end. The center of the element is a voltage null and feeding thusly eliminates the need for fancy gamma matching. The standing wave ratio (SWR) can be checked for each frequency and, if necessary, adjusted by trimming the open end of the driven element. If you don't have the means to check SWR, don't worry, as building the antenna to the dimensions given should provide a very close match and the true test will come when you actually operate.

2. The Diplexer.

Satellite antennas are cross-band antenna's that require a diplexer to split the frequencies to ensure the radio frequency (RF) energy goes to, or comes

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from, the intended portion of the antenna. To split the frequency, diplexers are installed in the feed lines between the radio and the two antennas. Diplexers use a combination of high-pass and low-pass filters to split the frequencies. Figure 2 shows a typical diplexer circuit using inductors and capacitors (L and C) based on values that I had available.

While designing my diplexer I found very little information to help me. Fortunately, Dale Heatherington, WA4DSY, has a calculator application on his website for designing LC low-pass and high-pass circuits, which simplified the process. I e-mailed Dale to find out if he could clear up some of the mystery surrounding filter design. He told me that he originally programmed the calculators for his own use because manually calculating filter component values was labor intensive.

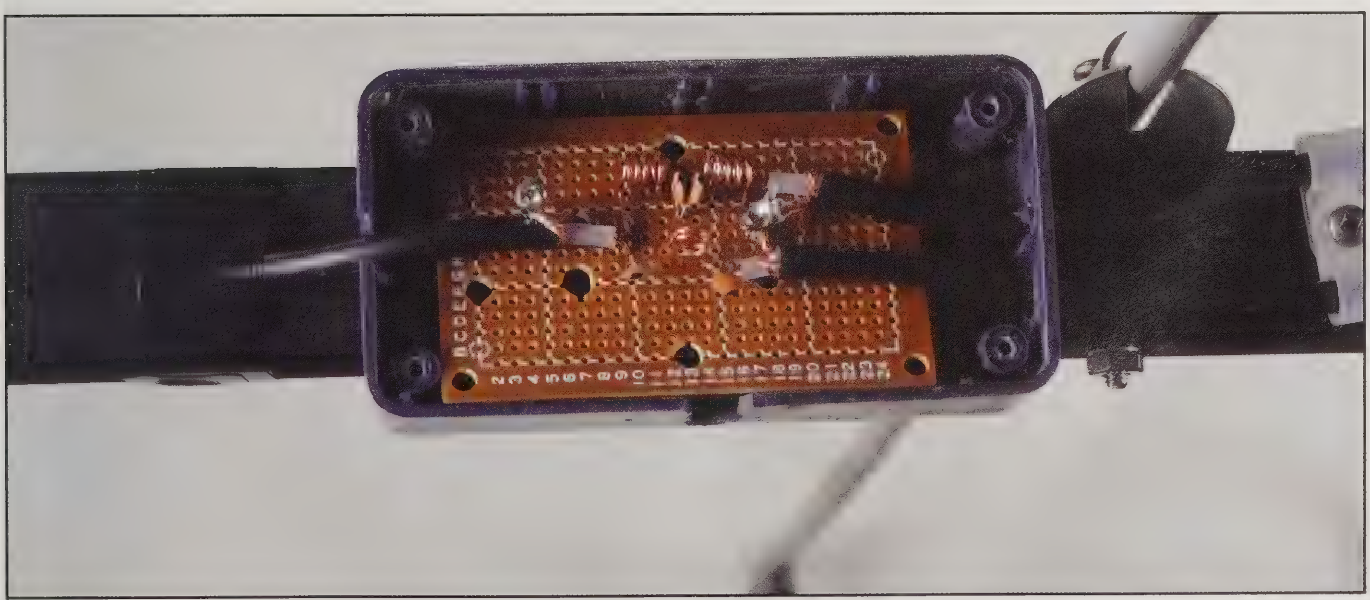

Photo D. Diplexer mounted to antenna.

"Writing a program to work the formulas and tables was a great time saver," he said. "I wrote them as web-based apps so I could use a web browser and make them available to anyone with internet access."

Heatherington's calculator requires several inputs from the user: design cut-off frequency, number of poles, and characteristic impedance.

Cut-off frequency is the point at which the filter has attenuated the incoming signal to the half-power point or 3 decibels (dB). Since satellites operate with an uplink frequency around 144 MHz and a downlink frequency around 430 to 450 MHz, a cutoff frequency anywhere from 225 to 375 MHz should produce acceptable results. I used a design cutoff frequency of 300 MHz. Heatherington cautions that the calculator produces component values that are ideal, not necessarily values that you will find in your parts box. "Users have to tweak the parameters until they get a compromise between rational parts values and performance," he said.

As for the design impedance, Heatherington says: "Set the I/O impedance to match the transmission line you are using." In my case that was 50-ohm RG-58 cables.

The last parameter to consider is the number of poles. For simplicity, I chose a three-pole design as shown in the schematic. Heatherington says additional poles can improve the performance of the filter.

"More poles improve the stop band rejection," he said. "Adding poles reduces the unwanted signals." However, there is a compromise, as increasing the number of components will increase the signal loss through the filter, something I didn't want to risk when receiving weak signals from a distant satellite.

Once the design parameters have been entered into Heatherington's calculator, it will output two different circuit configurations, complete with diagrams, and three sets of component values for Chebyshev, Butterworth, and Bessel style filters. Heatherington says Butterworth is the most popular:

"It has flat response in the pass-band and fairly good roll-off into the stop-band," he said, adding that all styles have advantages and disadvantages. "Chebyshev gives you steeper roll-off in the stop-band at the expense of ripples in the pass-band. The least popular is the Bessel, which has poor roll-off and stop-band rejection but has linear phase in the pass-band."

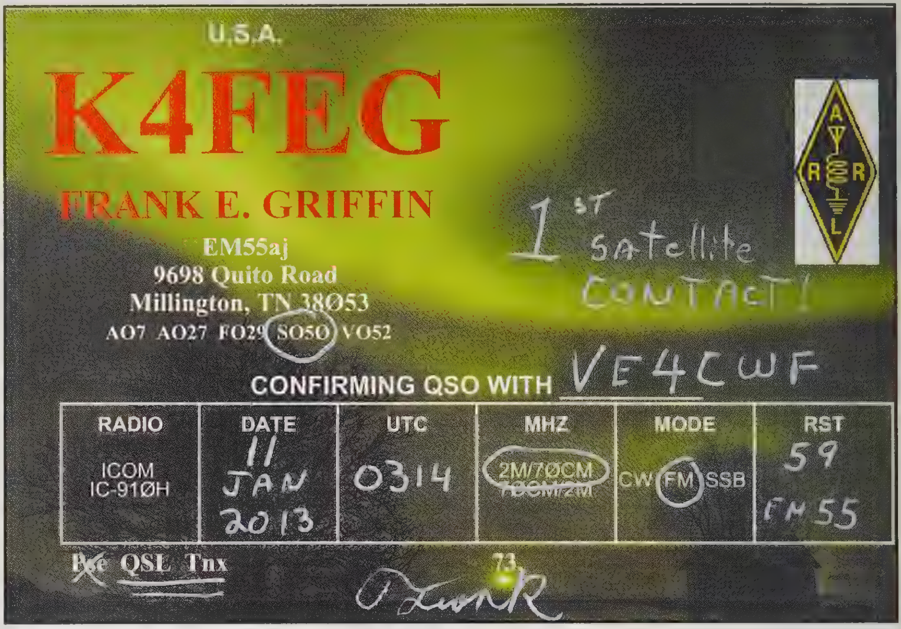

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Photo E. K4FEG QSL card.

I tweaked the filter design parameters enough to produce capacitor values close to values I had available. I then used another web-based calculator at <hamwaves.com/antennas/inductance.html> to design air-wound inductors with the correct inductance. I had to tweak the length of the coil and number of turns until I found a design that was a close match to the calculated values.

I built the diplexer on a piece of circuit board and installed it in a box on the side of the antenna, making the coax connections directly to the filter, again to reduce any insertion loss. The finished diplexer is shown in photo D. Note the two 10-pF capacitors in parallel to produce the 20 pF needed for the circuit.

3. Finishing touches.

Once the antenna was built, I mounted the diplexer box and neatly clamped the cables to the boom. Then I reinstalled the blade of the hockey stick. I have no means of checking SWR, so I went straight to the field test.

He Shoots, He Scores! (Testing and Operation)

The VE4MAN repeater is about 45 miles (70 km) from my home QTH, and on my first key-up I was able to hit the repeater while standing on the deck in my back yard. Darcy Wilson, VE4DDW, who was mobile at the time, gave me a report of full quieting. With his help I was also able to check the UHF portion of the antenna on transmit and receive. With these promising preliminary results, it was time to try the antenna on a high satellite pass.

On January 10, four days after the NHL lockout ended, I walked out into the field next to my house and made my first contact via the SO-50 satellite. Photo E shows the QSL card I received from Frank Griffin, K4FEG, a 1000 mile (1600 km) QSO. Since then I have made numerous other contacts, received my Satellite Communicator's Club award from AMSAT, and collected nine other cards on my way to the next award.

Satellite SO-50, I'm told, can be a tricky bird to work. However, with AMSAT working on two new satellites, and plans to deploy them in the next few years, now is the time to build a satellite antenna and begin operating. It need not be costly or complicated; just use what you have available and use some innovative thinking. Hopefully I will hear you scoring goals on the satellites, too.

Resources

Cheap Yagi Antenna Design: <www.wa5vjb.com>
Filter Design: <www.wa4dsy.net/filter/filterdesign.html>
Inductor Design: <hamwaves.com/antennas/inductance.html>
Floor Hockey Sticks: <www.canadiantire.ca>

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My VHF Contest Efforts on 222 MHz

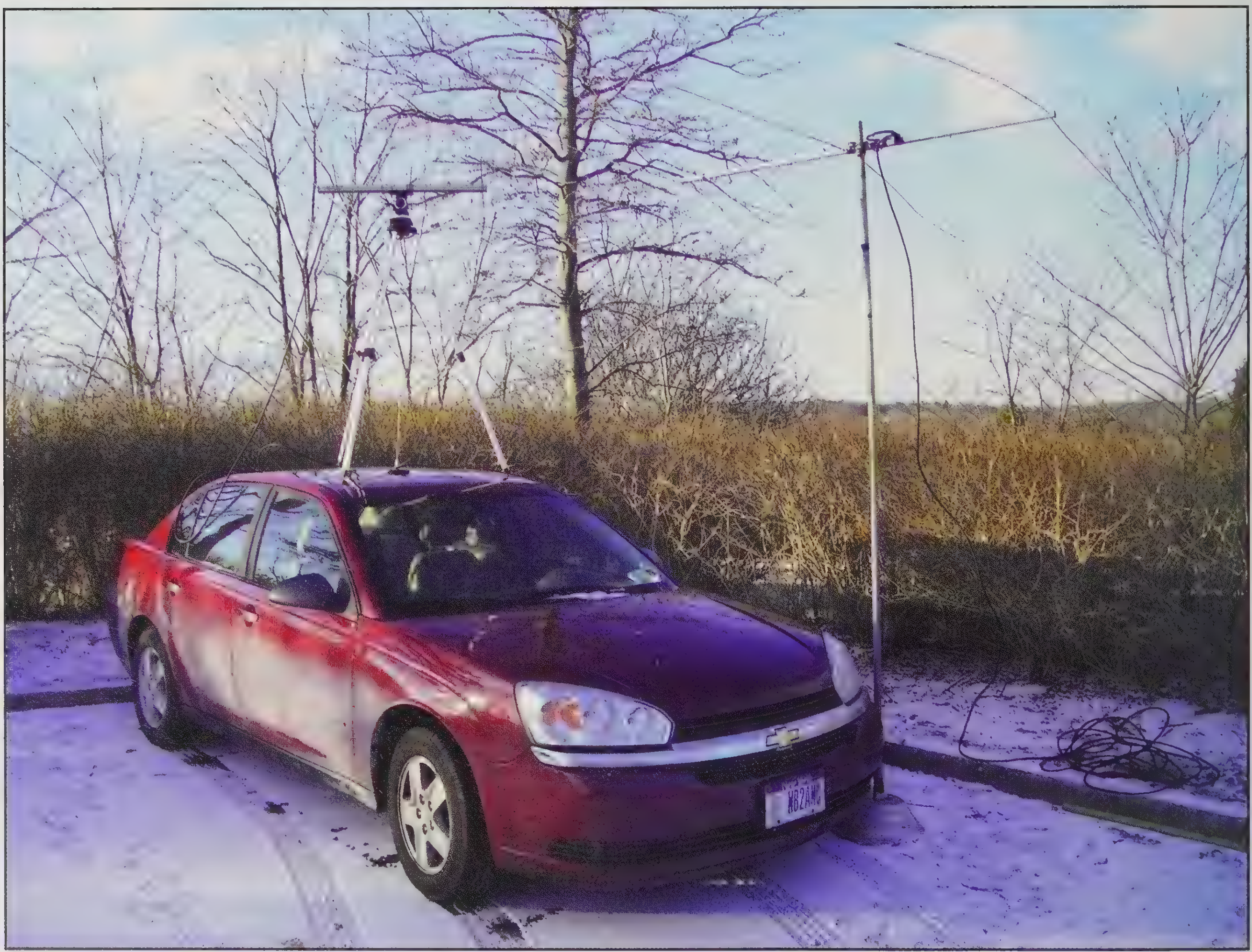
Lack of 50-MHz propagation is no deterrent for WB2AMU and his fire-red Chevy rover. In this article he describes how he and others are operating on 222 MHz during VHF contests.

By Ken Neubeck,* WB2AMU

I have been participating in the three annual ARRL VHF contests (January, June, and September) in the portable operator category for the past 20 years. My efforts started with operating 6 meters only, but then I bought a portable 2-meter, all-mode Yaesu FT-290 radio which increased my activity and score.

After obtaining the FT-100 and now the FT-857, I have added 432 MHz to my operating mix. The last of the lower four VHF bands, 222 MHz, remained a sort of enigma for me, as there are no easy options for this frequency as far as a simple all-mode setup for portable operations. Typically, one would need a transverter and separate power supply for all-mode on 222 MHz.

Some of the larger transceiver packages have options for including a 222-MHz module, which can be a bit of an expense. Also, the larger transceivers are not very easy to use for modest portable operations.



In this photo, you can make out the 222-MHz mag-mount vertical that is on the roof of the car and below the 2-meter tripod setup. (Photos by WB2AMU)

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*CQ VHF Features Editor
1 Valley Road, Patchogue, NY 11772
e-mail: <w2amu@cq-vhf.com>

Manufacturer	Model Number	Bands included (MHz)
Kenwood	TH-F6A	144, 222, 440
Yaesu	VX-6R	144, 222, 440
Yaesu	VX-8DR	50,144, 222, 440
Yaesu	VX-7R	50, 144, 222, 440
Alinco	DJ-G29T	222, 900
Wouxun	KG-UD3D	144, 222

Table 1. Author's selected list of commercially-available 222 MHz FM HTs.

For portable work, a transverter brings up the issue that a host radio (one of the existing radios) would be needed along with a separate power supply to power the transverter. This could add some level of complexity for a portable setup with regard to the amount of equipment that would be needed to be brought to an outdoor location. A key aspect of portable operation is to keep the setup as simple as possible.

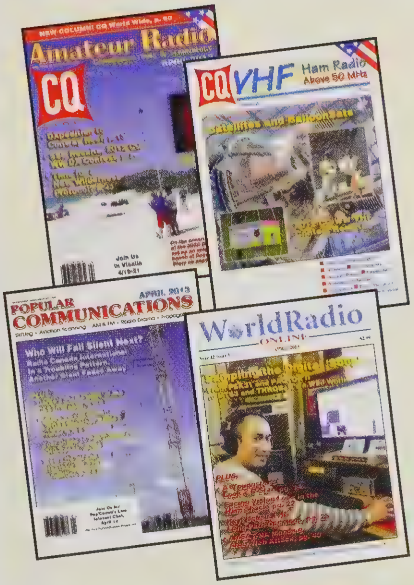
When one studies the scores and the band usage by the different stations participating in the ARRL VHF contests, 50, 144, and 432 MHz are the most active bands and in the mix for most stations. The addition of 222 MHz may not be practical, depending on where you are located, particularly if you are in a rural area away from population centers.

In previous articles written for *CQ VHF* magazine, I mentioned the idea that it would be great for a manufacturer to come up with an all-mode, 222-MHz radio. This is probably not going to happen in our lifetime for two reasons: (1) Many of the current radios are built in Japan, where 222 MHz is not an amateur radio band (although this band can easily be packaged with multi-mode FM radios imported to the US); and (2) there is not enough weak-signal activity in the US to justify a US manufacturer making such an all-mode radio by itself, compared to transverters.

However, after obtaining a Kenwood TH-F6 HT that had 144, 222, and 432 MHz, I looked at the possibility of using 222 MHz FM during the contests. Initially, this effort started with just the HT and the rubber-duck antenna with modest success in working others in my grid square. Then I graduated to a using mag-mount vertical on the car that was hooked up to the HT radio. A typical process for me to work stations during the VHF contests on 222 MHz was to first work a station on another VHF band, such as 50 MHz, and then walk them through 144 and 432 MHz for contacts. After the last contact, I would then ask the operators if they had 222 MHz FM capabilities, which a fair amount of stations do with their all-mode VHF radios.

The mag-mount vertical setup had its limitations, and often it could be a struggle to work some stations more than 40 miles away. However, I usually could get three to five contacts per contest from my portable hilltop location on Long Island, New York (FN30). Thus, the efforts to add 222 MHz in some form have added dividends to my overall contest scores. Typically, I can score two multipliers (FN30 and FN31) and five QSOs using the FM radio. This may not sound like much, but in the portable operator category this can be a significant number of contacts when conditions are poor and can represent between a 5- and 15-percent increase in my score,

One important aspect of this is that I am fortunate to be in a relatively high-population area of the New York tri-state



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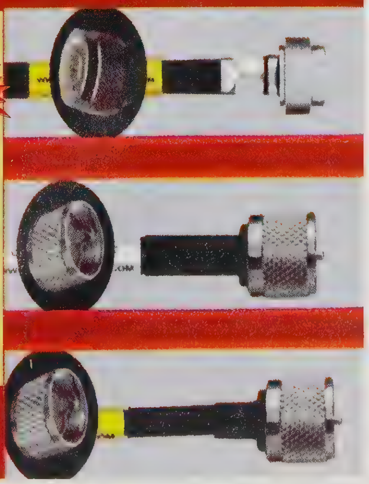


area. Here I can work a fair number of stations via line-of-sight using the 5-watt HT from a hilltop location. However, there is always room for improvements.

One such improvement came when my friend Jay Buscemi, NY2NY (ex-K2OVS), upgraded the antenna system of his 222-MHz station at home from a 3-element Yagi to a 10-element Yagi. He offered me the 3-element antenna, and I quickly accepted. With the January VHF contest coming up, I worked on making a setup using this antenna for the event.

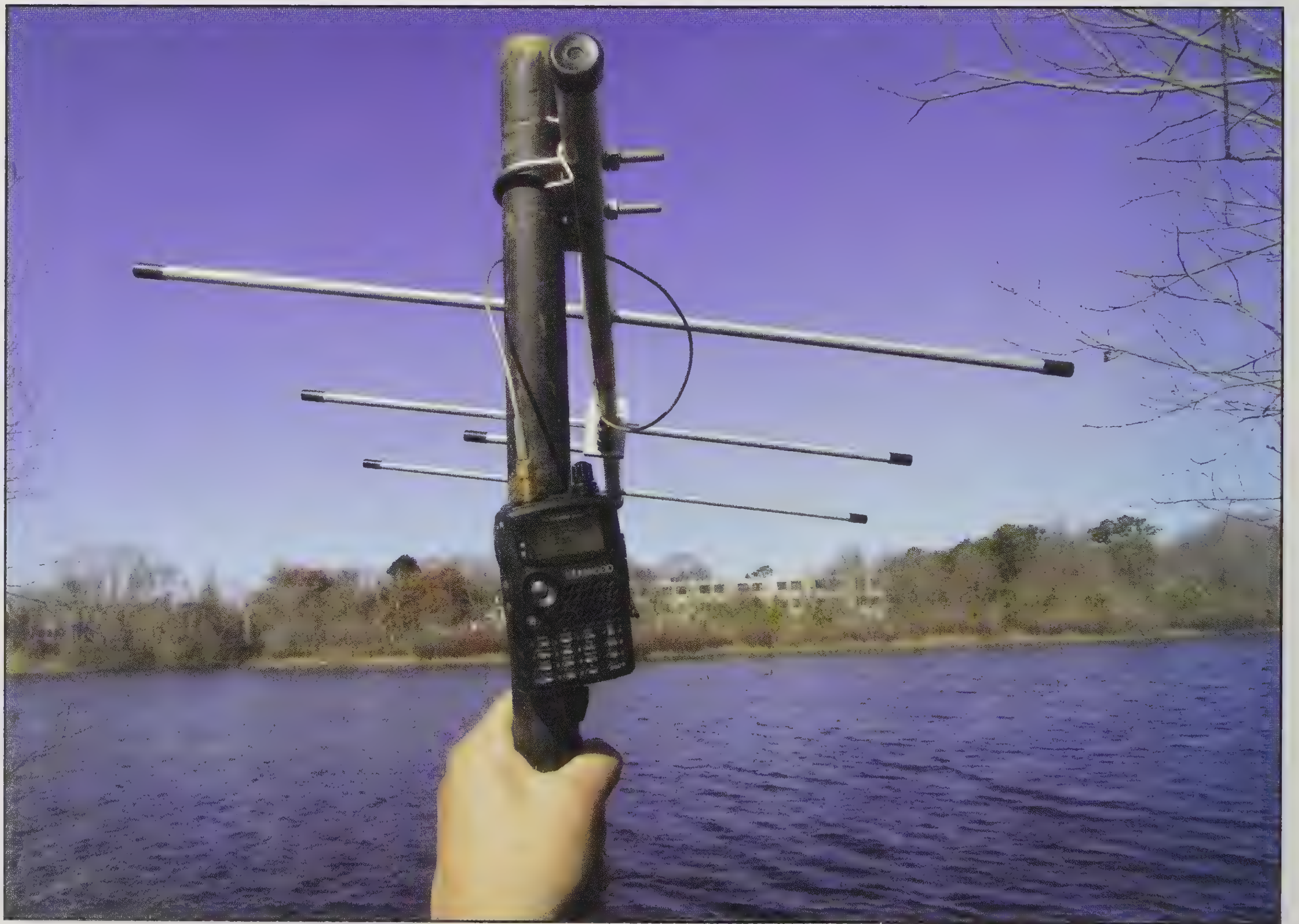
Rather than make a setup that would mount to the car, I decided on a truly portable setup with the antenna mounted on a 4-foot pole hook up with the radio. That would allow me total freedom in moving around on a hill and pointing in the optimal direction of the station I was trying to work.

When the January contest arrived, I had some issues with the wind affecting my 6-meter antenna setup, along with the presence of bad conditions during the daylight hours. Two meters was okay. However, I had the most fun during the contest when I was able to work stations in nearby grids when I talked them to 222 MHz FM and was able to use my improved beam on a stick setup. Buff Fisher, WB2SIH, is one of the operators in upstate NY in grid FN31 whom I usually try to move up the bands during the contests. The 222 MHz FM band usually was the toughest band for us to work in the past. This year I worked him with ease using the 3-element beam. I even worked Jay Buscemi, NY2NY, in FN30, who gave me the antenna.

Table 1 shows a list of some of the commercially available 5-watt HTs that are typically dual-band or tri-band and have 222 MHz FM capability.

Five watts with a directional antenna is sufficient for decent line-of-sight work from a hill in my area on the 222 MHz FM band. With the FM mode and this power level, weak signals are not going to be as easily worked as with the SSB and the CW modes. I had looked at the possibility of 900 MHz FM as another band to add for the contest. However, most of the radios that are available, typically in a dual-band package, only have $^1/2$ watt output. This is probably not going to be enough for practical use during any of the VHF contests, unless stations are only ten miles apart or less.

The point that I am making is that the likelihood of more 222-MHz weak-signal equipment to come along is slim. Also, on this band the FM mode makes the most sense because of the availability of equipment and relative ease with which to incorporate it in a contest setup. I think that the use of an HT for 222 MHz for portable operations is viable, and in some cases, 432 MHz FM may be another viable option for working local stations if one does not have this band in a multiband VHF all-mode transceiver.



This portable setup for 222 MHz FM consists of a commercially-made 3-element beam that is mounted on a short wooden pole to which the TH-F6 FM HT is mounted. It can quickly be turned by hand toward maximum signal strength.

CQ's 6 Meter and Satellite WAZ Awards

(As of April 1, 2013)

By Floyd Gerald,* N5FG, CQ WAZ Award Manager

6 Meter Worked All Zones

No.	Callsign	Zones needed to have all 40 confirmed
1	N4CH	16,17,18,19,20,21,22,23,24,25,26,28,29,34,39
2	N4MM	17,18,19,21,22,23,24,26.28.29,34
3	JI1CQA	2,18,34,40
4	K5UR	2,16,17,18,19,21,22,23,24,26,27,28,29,34,39
5	EH7KW	1,2,6,18,19,23
6	K6EID	17,18,19,21,22,23,24,26,28,29,34,39
7	K0FF	16,17,18,19,20,21,22,23,24,26,27,28,29,34
8	JF1IRW	2,40
9	K2ZD	2,16,17,18,19,21,22,23,24,26, 28,29,34
10	W4VHF	16,17,18,19,21,22,23,24,25,26,28,29,34,39
11	G0LCS	1,6,7,12,18,19,22,23,28,31
12	JR2AUE	2,18,34,40
13	K2MUB	16,17,18,19,21,22,23,24,26,28,29,34
14	AE4RO	16,17,18,19,21,22,23,24,26,28,29,34,37
15	DL3DXX	18,19,23,31,32
16	W5OZI	2,16,17,18,19,20,21,22,23,24,26,28,34,39,40
17	WA6PEV	3,4,16,17,18,19,20,21,22,23,24,26,29,34,39
18	9A8A	1,2,3,6,7,10,12,18,19,23,31
19	9A3JI	1,2,3,4,6,7,10,12,18,19,23,26,29,31,32
20	SP5EWY	1,2,3,4,6,9,10,12,18,19,23,26,31,32
21	W8PAT	16,17,18,19,20,21,22,23,24,26,28,29,30,34,39
22	K4CKS	16,17,18,19,21,22,23,24,26,28,29,34,36,39
23	HB9RUZ	1,2,3,6,7,9,10,18,19,23,31,32
24	JA3IW	2,5,18,34,40
25	IK1GPG	1,2,3,6,10,12,18,19,23,32
26	W1AIM	16,17,18,19,20,21,22,23,24,26,28,29,30,34
27	K1LPS	16,17,18,19,21,22,23,24,26,27,28,29,30,34,37
28	W3NZL	17,18,19,21,22,23,24,26,27,28,29,34
29	K1AE	2,16,17,18,19,21,22,23,24,25,26,28,29,30,34,36
30	IW9CER	1,2,6,18,19,23,26,29,32
31	IT9IPQ	1,2,3,6,18,19,23,26,29,32
32	G4BWP	1,2,3,6,12,18,19,22,23,24,30,31,32
33	LZ2CC	1
34	K6MIO/KH6	16,17,18,19,23,26,34,35,37,40
35	K3KYR	17,18,19,21,22,23,24,25,26,28,29,30,34
36	YV1DIG	1,2,17,18,19,21,23,24,26,27,29,34,40
37	K0AZ	16,17,18,19,21,22,23,24,26,28,29,34,39
38	WB8XX	17,18,19,21,22,23,24,26,28,29,34,37,39
39	K1MS	2,17,18,19,21,22,23,24,25,26,28,29,30,34
40	ES2RJ	1,2,3,10,12,13,19,23,32,39
41	NW5E	17,18,19,21,22,23,24,26,27,28,29,30,34,37,39
42	ON4AOI	1,18,19,23,32
43	N3DB	17,18,19,21,22,23,24,25,26,27,28,29,30,34,36
44	K4ZOO	2,16,17,18,19,21,22,23,24,25,26,27,28,29,34
45	G3VOF	1,3,12,18,19,23,28,29,31,32
46	ES2WX	1,2,3,10,12,13,19,31,32,39
47	IW2CAM	1,2,3,6,9,10,12,18,19,22,23,27,28,29,32
48	OE4WHG	1,2,3,6,7,10,12,13,18,19,23,28,32,40
49	TI5KD	2,17,18,19,21,22,23,26,27,34,35,37,38,39
50	W9RPM	2,17,18,19,21,22,23,24,26,29,34,37
51	N8KOL	17,18,19,21,22,23,24,26,28,29,30,34,35,39
52	K2YOF	17,18,19,21,22,23,24,25,26,28,29,30,32,34
53	WA1ECF	17,18,19,21,23,24,25,26,27,28,29,30,34,36
54	W4TJ	17,18,19,21,22,23,24,25,26,27,28,29,34,39
55	JM1SZY	2,18,34,40
56	SM6FHZ	1,2,3,6,12,18,19,23,31,32
57	N6KK	15,16,17,18,19,20,21,22,23,24,34,35,37,38,40
58	NH7RO	1,2,17,18,19,21,22,23,28,34,35,37,38,39,40
59	OK1MP	1,2,3,10,13,18,19,23,28,32
60	W9JUV	2,17,18,19,21,22,23,24,26,28,29,30,34
61	K9AB	2,16,17,18,19,21,22,23,24,26,28,29,30,34
62	W2MPK	2,12,17,18,19,21,22,23,24,26,28,29,30,34,36
63	K3XA	17,18,19,21,22,23,24,25,26,27,28,29,30,34,36
64	KB4CRT	2,17,18,19,21,22,23,24,26,28,29,34,36,37,39
65	JH7IFR	2,5,9,10,18,23,34,36,38,40
66	K0SQ	16,17,18,19,20,21,22,23,24,26,28,29,34
67	W3TC	17,18,19,21,22,23,24,26,28,29,30,34
68	IK0PEA	1,2,3,6,7,10,18,19,22,23,26,28,29,31,32
69	W4UDH	16,17,18,19,21,22,23,24,26,27,28,29,30,34,39
70	VR2XMT	2,5,6,9,18,23,40
71	EH9IB	1,2,3,6,10,17,18,19,23,27,28
72	K4MQG	17,18,19,21,22,23,24,25,26,28,29,30,34,39
73	JF6EZY	2,4,5,6,9,19,34,35,36,40
74	VE1YX	17,18,19,23,24,26,28,29,30,34
75	OK1VBN	1,2,3,6,7,10,12,18,19,22,23,24,32,34
76	UT7QF	1,2,3,6,10,12,13,19,24,26,30,31
77	K5NA	16,17,18,19,21,22,23,24,26,28,29,33,37,39
78	I4EAT	1,2,6,10,18,19,23,32
79	W3BTX	17,18,19,22,23,26,34,38
80	JH1HHC	2,5,7,9,18,34,35,37,40.
81	PY2RO	1,2,17,184OM,19,21,22,23,26,28,29,30,38,39,40
82	W4UM	18,19,21,22,23,24,26,27,28,29,34,37,39
83	I5KG	1,2,3,6,10,18,19,23,27,29,32.
84	DF3CB	1,18,19,32
85	K4PI	17,18,19,21,22,23,24,26,28,29,30,34,37,38,39.
86	WB8TGY	16,17,18,19,21,22,23,24,26,28.29,30,34,36,39
87	MU0FAL	1,2,12,18,19,22,23,24,26,27,28,29,30,31,32
88	PY2BW	1,2,17,18,19,22,23,26,28,29,30,38,39,40.
89	K4OM	17,18,19,21,22,23,24,26,28,29,32,34,36,38,39.
90	JH0BBE	2,33,34,40
91	K6QXY	17,18,19,21,22,23,34,37,39
92	JA8ISU	2,7,8,9,19,33,34,36,37,38,39,40
93	YO9HP	1,2,6,7,11,12,13,18,19,23,28,29,30,31,40
94	SV8CS	1,2,18,19,29
95	SM3NRY	1,6,10,12,13,19,23,25,26,29,30,31,32,39
96	VK3OT	2,10,11,12,16,34,35,37,39,40
97	UY1HY	1,2,3,6,7,9,12,18,19,23,26.28,31,32,36
98	JA7QVI	2,40
99	K1HTV	17,18,19,21,22,23,24,26,28,29,34
100	OK1RD	2,7,8,9,11,13,18,19,21,22,28,39,40
101	S51DI	1,2,6,18,19
102	S59Z	1,2,6,7,10,12,17,18,19,22,23,24,26,31,32
103	UY5ZZ	1,2,3,6,7,10,11,12,13,18,19,29,31,32,39
104	UX0FF	1,2,6,7,10,12,13,18,19,22,28,29,31,32
105	EI3IO	1,3,12,18,19,23,29,30,31,32
106	JJ2BLV	2,4,5,7,8,9,16,18,19,34,35,36,37,38,40
107	EA6SX	1,2,10,12,18,19,22,26,27,28,29,30,31,32.
108	PE5T	1,2,3,6,12,18,19,22,27,29,30,31,32,39
109	SP3RNZ	1,2,3,6,7,13,18,19,23,24,26,28,31,32
110	W9VHF	17,18,19,21,22,23,24,26,28,29,30,34,36,39
111	UT5URW	1,2,3,4,6,7,10,11,12,18,19,29,30,31,32
112	KR7O	18,19,21,22,23,26,28,33,34,35,36,37,39,40
113	K8SIX	19,13,17,18,19,21,22,23,24,26,29,30,34,37

Satellite Worked All Zones

No.	Callsign	Issue date	Zones Needed to have all 40 confirmed
1	KL7GRF	8 Mar. 93	None
2	VE6LQ	31 Mar. 93	None
3	KD6PY	1 June 93	None
4	OH5LK	23 June 93	None
5	AA6PJ	21 July 93	None
6	K7HDK	9 Sept. 93	None
7	W1NU	13 Oct. 93	None
8	DC8TS	29 Oct. 93	None
9	DG2SBW	12 Jan. 94	None
10	N4SU	20 Jan. 94	None
11	PA0AND	17 Feb. 94	None
12	VE3NPC	16 Mar. 94	None
13	WB4MLE	31 Mar. 94	None
14	OE3JIS	28 Feb. 95	None
15	JA1BLC	10 Apr. 97	None
16	F5ETM	30 Oct. 97	None
17	KE4SCY	15 Apr. 01	10,18,19,22,23, 24,26,27,28, 29,34,35,37,39
18	N6KK	15 Dec. 02	None
19	DL2AYK	7 May 03	2,10,19,29,34
20	N1HOQ	31 Jan. 04	10,13,18,19,23, 24,26,27,28,29, 33,34,36,37,39
21	AA6NP	12 Feb. 04	None
22	9V1XE	14 Aug. 04	2,5,7,8,9,10,12,13, 23,34,35,36,37,40
23	VR2XMT	01 May 06	2,5,8,9,10,11,12,13,23,34,40
24	XE1MEX	19 Mar. 09	2,17,18,21,22,23,26,34,37,40
25	KC0TO	17 Mar. 11	None
26	TI5RLI	10 July 12	2,16,19,22,23,24,26,34

CQ offers the Satellite Work All Zones award for stations who confirm a minimum of 25 zones worked via amateur radio satellite. In 2001 we "lowered the bar" from the original 40 zone requirement to encourage participation in this very difficult award. A Satellite WAZ certificate will indicate the number of zones that are confirmed when the applicant first applies for the award.

Endorsement stickers are not offered for this award. However, an embossed, gold seal will be issued to you when you finally confirm that last zone.

Rules and applications for the WAZ program may be obtained by sending a large SAE with two units of postage or an address label and $1.00 to the WAZ Award Manager: Floyd Gerald, N5FG, P.O. Box 449, Wiggins, MS 39577-0449. The processing fee for all CQ awards is $6.00 for subscribers (please include your most recent *CQ* or *CQ VHF* mailing label or a copy) and $12.00 for nonsubscribers. Please make all checks payable to Floyd Gerald. Applicants sending QSL cards to a CQ Checkpoint or the Award Manager must include return postage. N5FG may also be reached via e-mail: <n5fg@cq-amateur-radio.com>.

**P.O. Box 449, Wiggins, MS 39577-0449; e-mail: <n5fg@cq-amateur-radio.com>*

By Bob Witte,* K0NR

FM

FM/Repeaters—Inside Amateur Radio's "Utility" Mode

A Little Mountaintop Operation

Amateur radio operators have this habit of taking their radio gear with them when doing other activities. One example is operating mobile from a car, which is a common use of amateur radio. Another example is taking ham gear on a camping trip or to the beach, combining ham radio with another fun activity. These *crossover activities* are a great way to enjoy the hobby.

One of my favorite crossover activities is operating VHF from a mountaintop, often as part of hiking or climbing outing. With the Rocky Mountains just to the west of my house, it is a natural thing to do. It is well known that Height Above Average Terrain (HAAT) greatly increases the operating range on frequencies above 50 MHz.

Summits On The Air (SOTA)

The Summits On The Air (SOTA) program has really taken off in North America. SOTA originated in the UK in 2002, so it took a little while for it to make it across the Atlantic to this continent. The basic idea of SOTA is to operate from a designated list of summits or to work other radio operators when they activate the summits. The list of designated summits is assigned scoring points based on elevation and there are scoring systems for both *activators* (radio operators on a summit) and *chasers* (radio operators working someone on a summit). I won't cover the complete details here, so use the SOTA links listed in the reference section to learn the whole story.

The SOTA program has been around long enough to have some impressive infrastructure supporting it. The SOTA database is the online system that is used to capture all QSO information for *SOTA*

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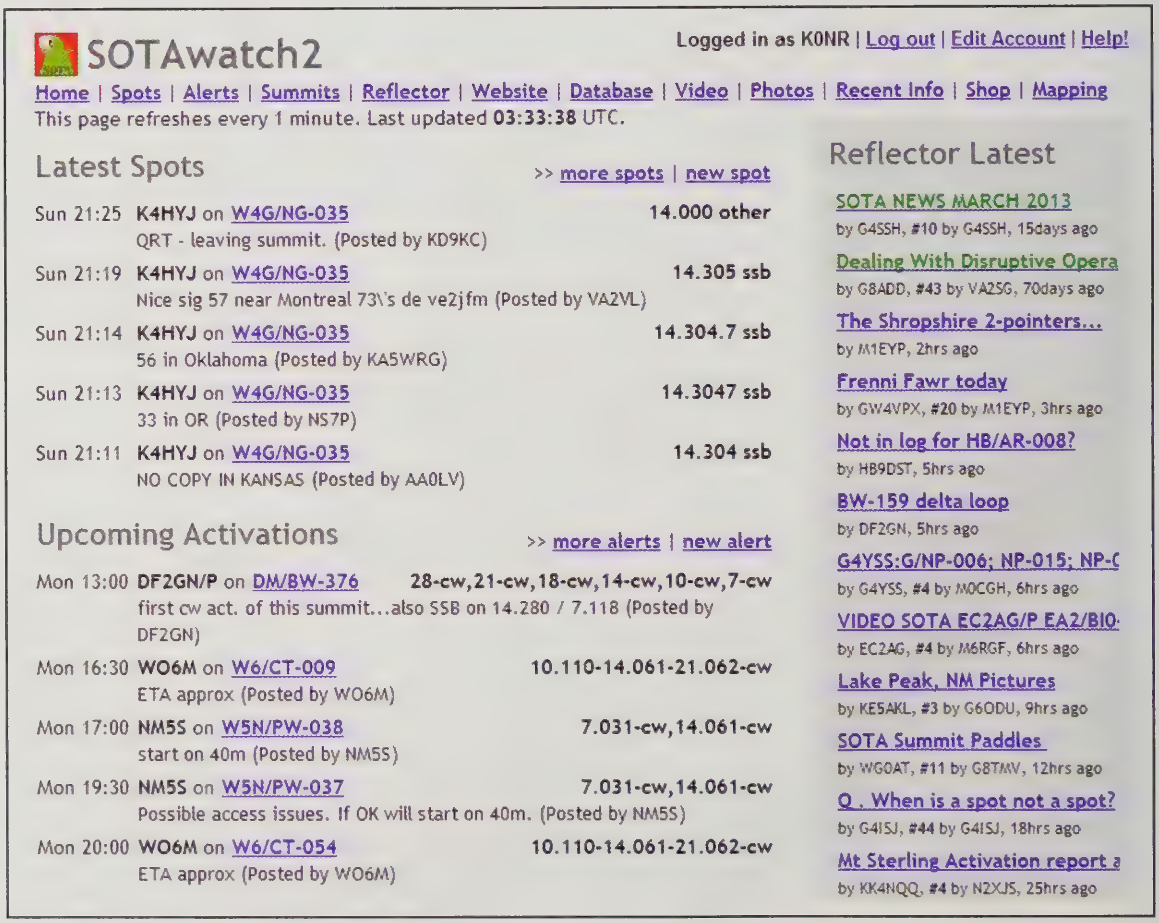
*21060 Capella Drive, Monument, CO 80132
e-mail: <bob@k0nr.com>



SOTAwatch2

Logged in as K0NR | Log out | Edit Account | Help!

Home | Spots | Alerts | Summits | Reflector | Website | Database | Video | Photos | Recent Info | Shop | Mapping

This page refreshes every 1 minute. Last updated **03:33:38** UTC.

Latest Spots

>> more spots | new spot

Sun 21:25 **K4HYJ** on W4G/NG-035 **14.000 other**
QRT - leaving summit. (Posted by KD9KC)

Sun 21:19 **K4HYJ** on W4G/NG-035 **14.305 ssb**
Nice sig 57 near Montreal 73\'s de ve2jfm (Posted by VA2VL)

Sun 21:14 **K4HYJ** on W4G/NG-035 **14.304.7 ssb**
56 in Oklahoma (Posted by KA5WRG)

Sun 21:13 **K4HYJ** on W4G/NG-035 **14.3047 ssb**
33 in OR (Posted by NS7P)

Sun 21:11 **K4HYJ** on W4G/NG-035 **14.304 ssb**
NO COPY IN KANSAS (Posted by AA0LV)

Upcoming Activations

>> more alerts | new alert

Mon 13:00 **DF2GN/P** on DM/BW-376 **28-cw,21-cw,18-cw,14-cw,10-cw,7-cw**
first cw act. of this summit...also SSB on 14.280 / 7.118 (Posted by DF2GN)

Mon 16:30 **WO6M** on W6/CT-009 **10.110-14.061-21.062-cw**
ETA approx (Posted by WO6M)

Mon 17:00 **NM5S** on W5N/PW-038 **7.031-cw,14.061-cw**
start on 40m (Posted by NM5S)

Mon 19:30 **NM5S** on W5N/PW-037 **7.031-cw,14.061-cw**
Possible access issues. If OK will start on 40m. (Posted by NM5S)

Mon 20:00 **WO6M** on W6/CT-054 **10.110-14.061-21.062-cw**
ETA approx (Posted by WO6M)

Reflector Latest

SOTA NEWS MARCH 2013
by G4SSH, #10 by G4SSH, 15days ago

Dealing With Disruptive Opera
by G8ADD, #43 by VA2SG, 70days ago

The Shropshire 2-pointers...
by M1EYP, 2hrs ago

Frenni Fawr today
by GW4VPX, #20 by M1EYP, 3hrs ago

Not in log for HB/AR-008?
by HB9DST, 5hrs ago

BW-159 delta loop
by DF2GN, 5hrs ago

G4YSS:G/NP-006; NP-015; NP-
by G4YSS, #4 by M0CGH, 6hrs ago

VIDEO SOTA EC2AG/P EA2/BIO
by EC2AG, #4 by M6RGF, 6hrs ago

Lake Peak, NM Pictures
by KE5AKL, #3 by G6ODU, 9hrs ago

SOTA Summit Paddles
by WG0AT, #11 by G8TMV, 12hrs ago

Q . When is a spot not a spot?
by G4ISJ, #44 by G4ISJ, 18hrs ago

Mt Sterling Activation report
by KK4NQQ, #4 by N2XJS, 25hrs ago

Figure 1. The SOTAwatch web page is a great place to share upcoming SOTA activations and to spot SOTA operators when they come on the air.

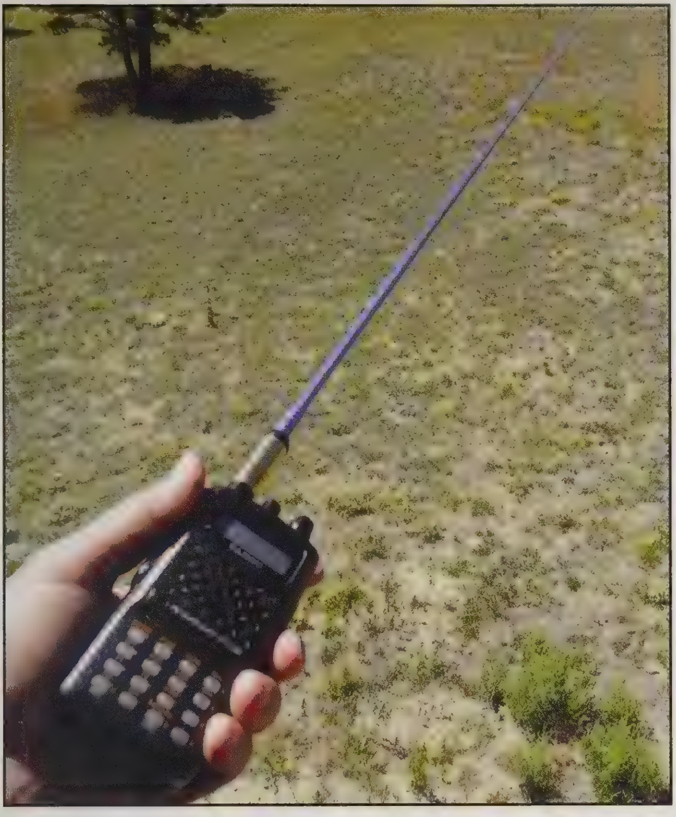


Figure 2. A half-wave antenna for 2 meters is a great improvement over the standard rubber-duck antenna. Shown here is an FT-60 transceiver being used with an MFJ-1714 half-wave antenna.

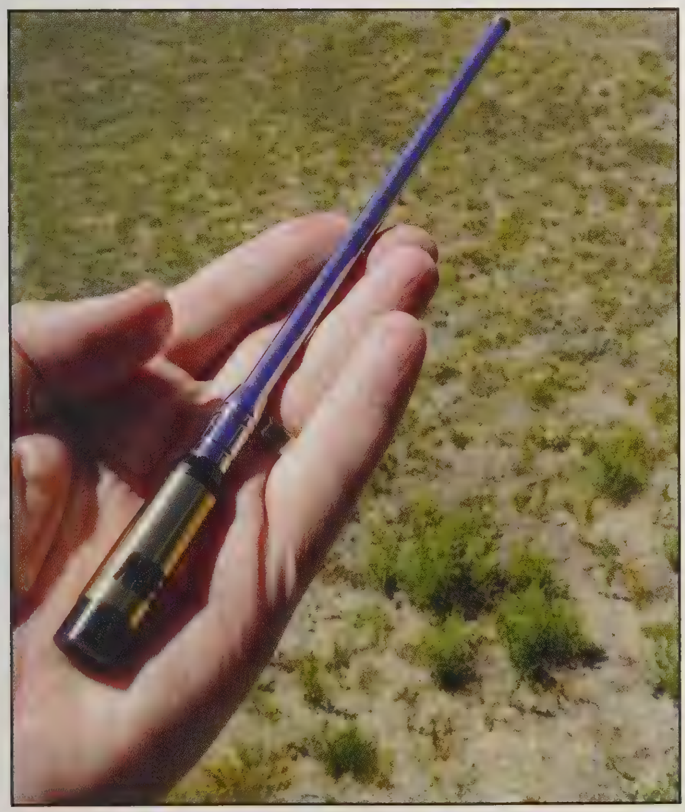


Figure 3. The half-wave antenna collapses down to a convenient size for storage and transportation.

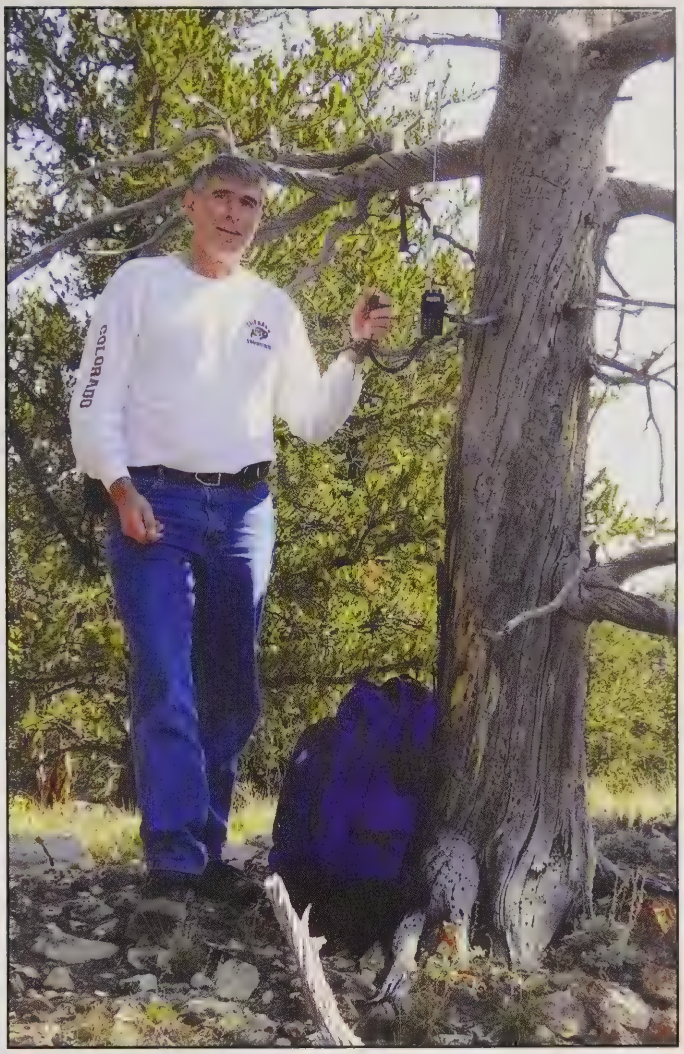


Figure 4. Bob, K0NR, operating from Kaufmann Ridge, using the basic VHF SOTA station (HT plus half-wave antenna). (Photo: Joyce, K0JJW)

peaks and calculate scores of activators and chasers. QSL cards are not required, so you just have to enter your log information. The *SOTAwatch* website is the place that activators post their future plans for operating from a summit (figure 1). When activators are heard on the air, chasers "spot them" on SOTAwatch so the other SOTA enthusiasts know the summit is active. The SOTAwatch site also has links to useful reference information on each summit, including latitude/longitude, elevation, location maps, and trip reports.

Most of the operating is on the HF bands, but there are quite a few VHF contacts on SOTA. Obviously, HF has the advantage of being able to work greater distances without too much trouble. Typically, the HF station is your classic portable QRP rig, portable antenna, and battery power. (A portable power source is required and the use of fossil fuels is prohibited.) Being a VHF enthusiast, I prefer the challenge of making contacts above 50 MHz, so my SOTA contacts are usually on 2 meters or 70 cm.

My basic VHF SOTA station is a handheld FM transceiver with a $^1/2$-wave telescoping antenna (figures 2 and 3). The standard rubber duck on a handheld transceiver (HT) is generally a poor radiator, so using a $^1/2$-wave antenna is a huge improvement. This simple station is an easy addition to my normal hiking routine … just stuff the HT and antenna in my backpack along with the usual hiking essentials and head for the summit (figure 4). Sometimes I'll take along a speaker/mic and hang the HT in a tree to keep the antenna as high as possible (figure 5).

To count as a SOTA activation, you need to make a minimum of four contacts from the summit. If I am hiking a summit within range of a major city, I can usually just make some random contacts by calling CQ on the National Simplex Calling Frequency, 146.52 MHz. However, operating in more remote areas requires a little more planning. I'd hate to hike all that way and come up short on the required contacts, so I use a few tactics to rustle up some VHF contacts. Of course, I post my planned activation on the SOTAwatch site in advance to let people know that I'll be on the air. While this goes out worldwide, it may not reach the right radio amateurs within VHF range. The next thing I do is send an e-mail to some of VHF-equipped hams I know will be within range. Many people respond to such a request to work a summit, even if they are not active in SOTA. When on the summit, my first call is on 146.52 MHz or some other popular simplex frequency. If I don't raise anyone there, I make a call on a few of the 2-meter repeaters in the area to see if someone will come over to "five two" to make a contact. SOTA does not recognize repeater contacts, but it is okay to solicit simplex contacts using a repeater. These techniques and a little patience have always gotten me at least four contacts, and usually quite a few more.

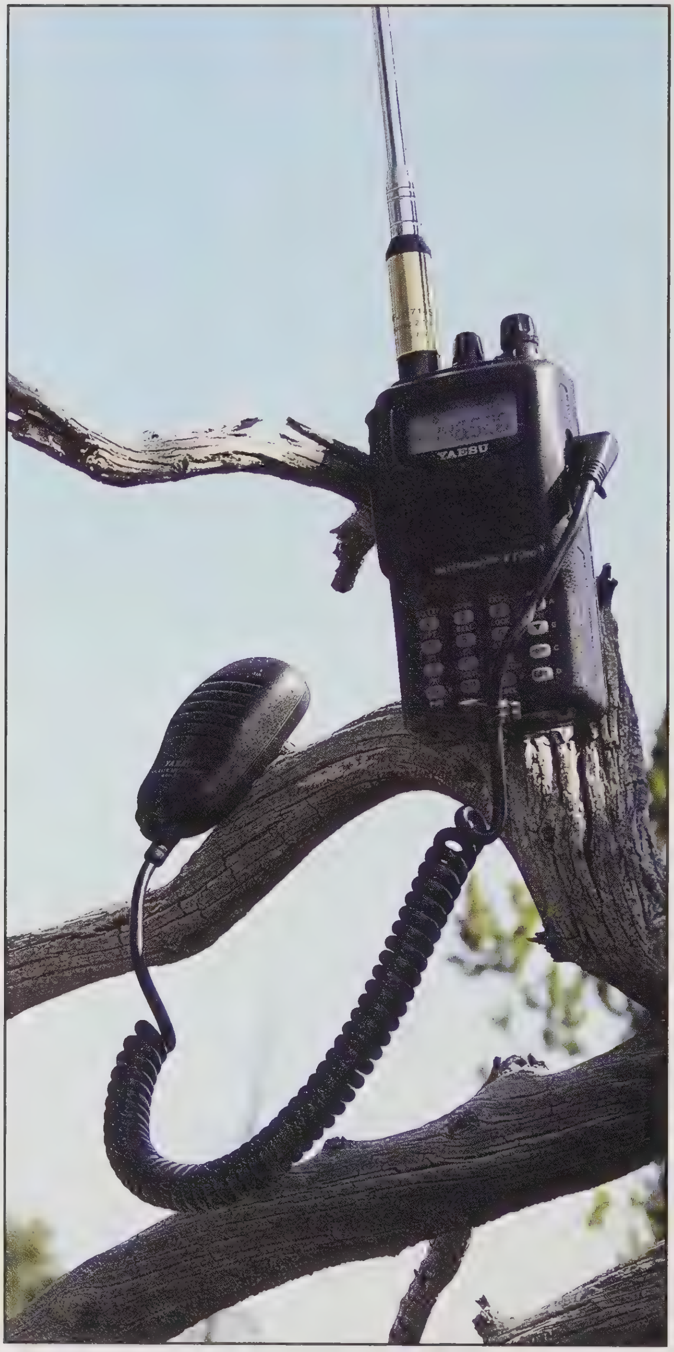


Figure 5. The innovative HT-in-a-tree mounting technique for SOTA activations.

Colorado 14er Event

For over two decades, we've held an annual event in Colorado called the Colorado 14er Event. On the Sunday of the first full weekend in August, radio amateurs operate from the summits

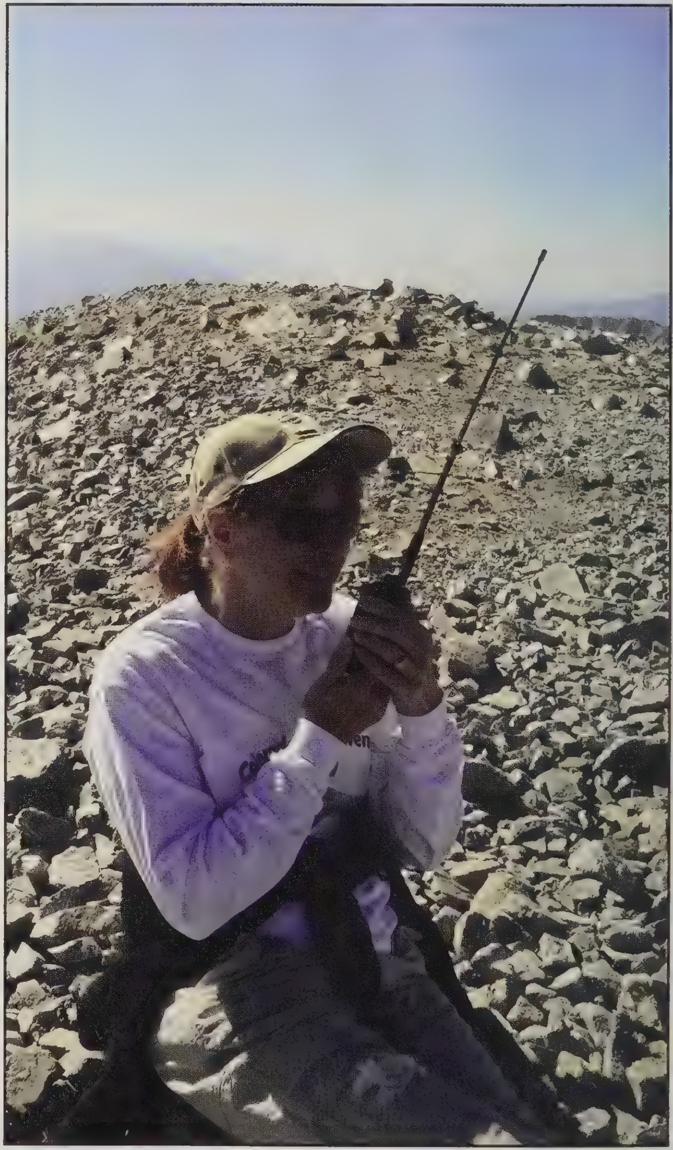


Figure 6. Joyce, KØJWW, operates on 70 cm from the summit of Mount Antero during the Colorado 14er Event.

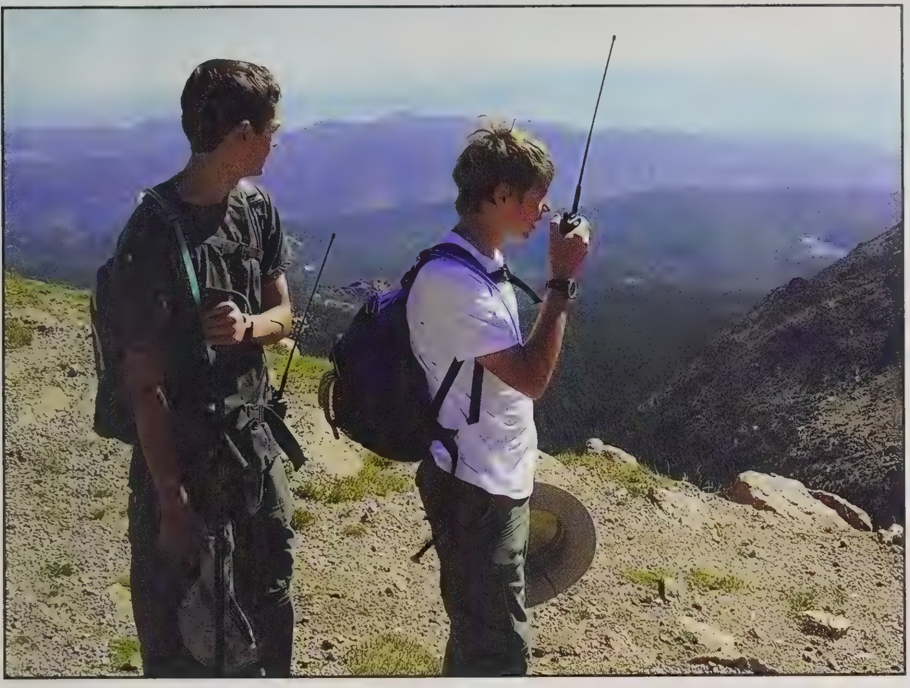


Figure 7. Ethan, KD0MFP, and Cole, W0COL, pause on the trail up Pikes Peak. (Photo: Stu, W0STU)

of the 14,000-foot (or higher) mountains of Colorado (figures 6 and 7). There are 54 of these 14er mountains, most of them climbable without technical skill, but none are easy. Two summits, Pikes Peak and Mount Evans, have roads to the top. Typically, we've had 18 to 24 of the peaks active during the event, mostly on VHF but some on HF.

Starting in 2012, the 14er event now includes SOTA mountaintop activations. With over 1500 SOTA peaks in the state, it dramatically increases the number of opportunities for mountaintop operating. The SOTA database includes most, but not all, of the 54 Colorado 14ers. The difference between the two lists results from using a different criteria to define a distinct summit. (See the Colorado 14er Event website for the details.) The great thing about the SOTA list is that there are summits that are much easier to climb, compared to the 14ers, so it opens up the event to a wide range of people. The SOTA program does require "non-motorized final ascent," which means that you have to take yourself and carry your gear to the summit. It is acceptable to drive to a summit, hike down a prescribed distance (about 100 to 175 vertical feet), and then return to the summit carrying your equipment. The intent of this rule is to encourage human-powered activity and to exclude operating from a vehicle. This is another area in which you should read the fine print in the SOTA rules for your area of the country.

More Signal

The omnidirectional antenna of the basic VHF SOTA station will make some contacts, and adding some antenna gain can really help your signal. There are a number of compact directional antennas

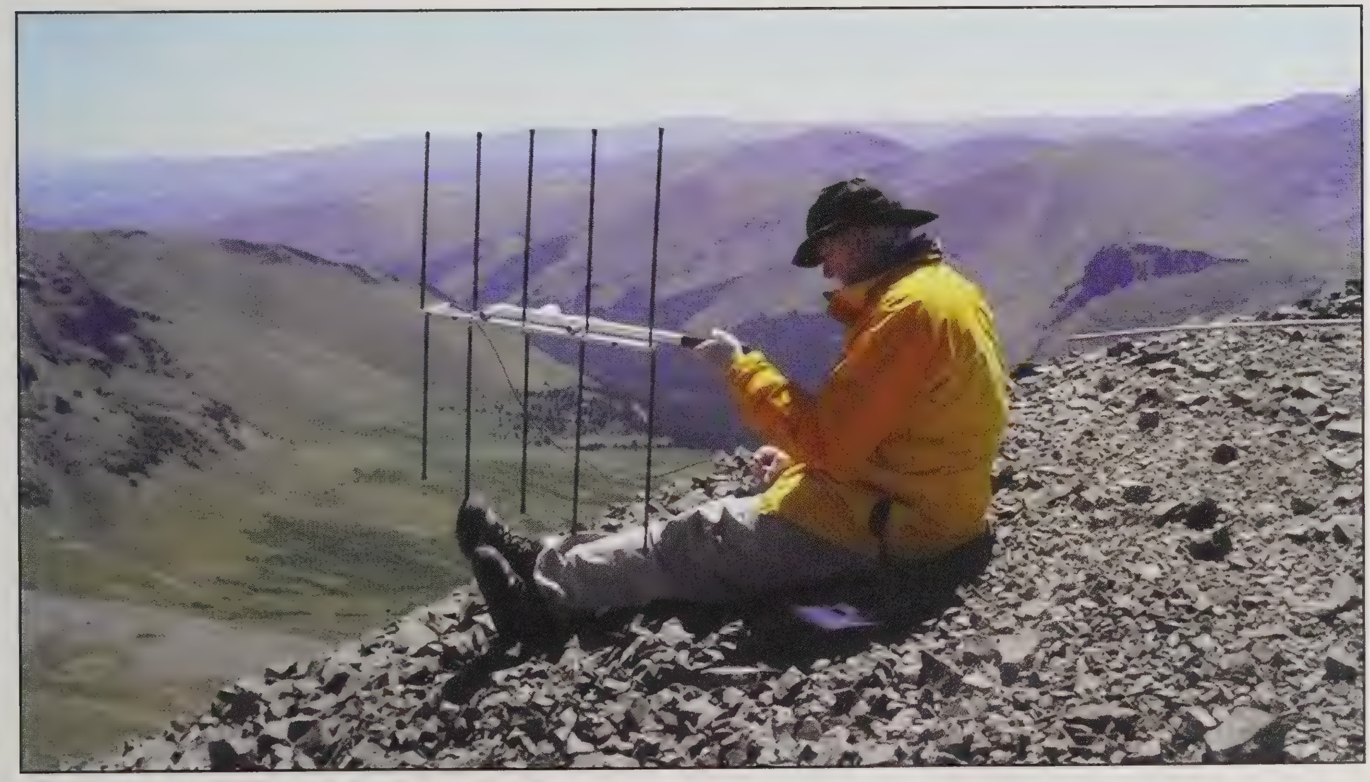


Figure 8. Scott, AC0FQ, uses an Elk log-periodic antenna to make contacts on VHF from San Luis Peak in the Colorado 14er Event. (Photo: Judy, KD0GUY)

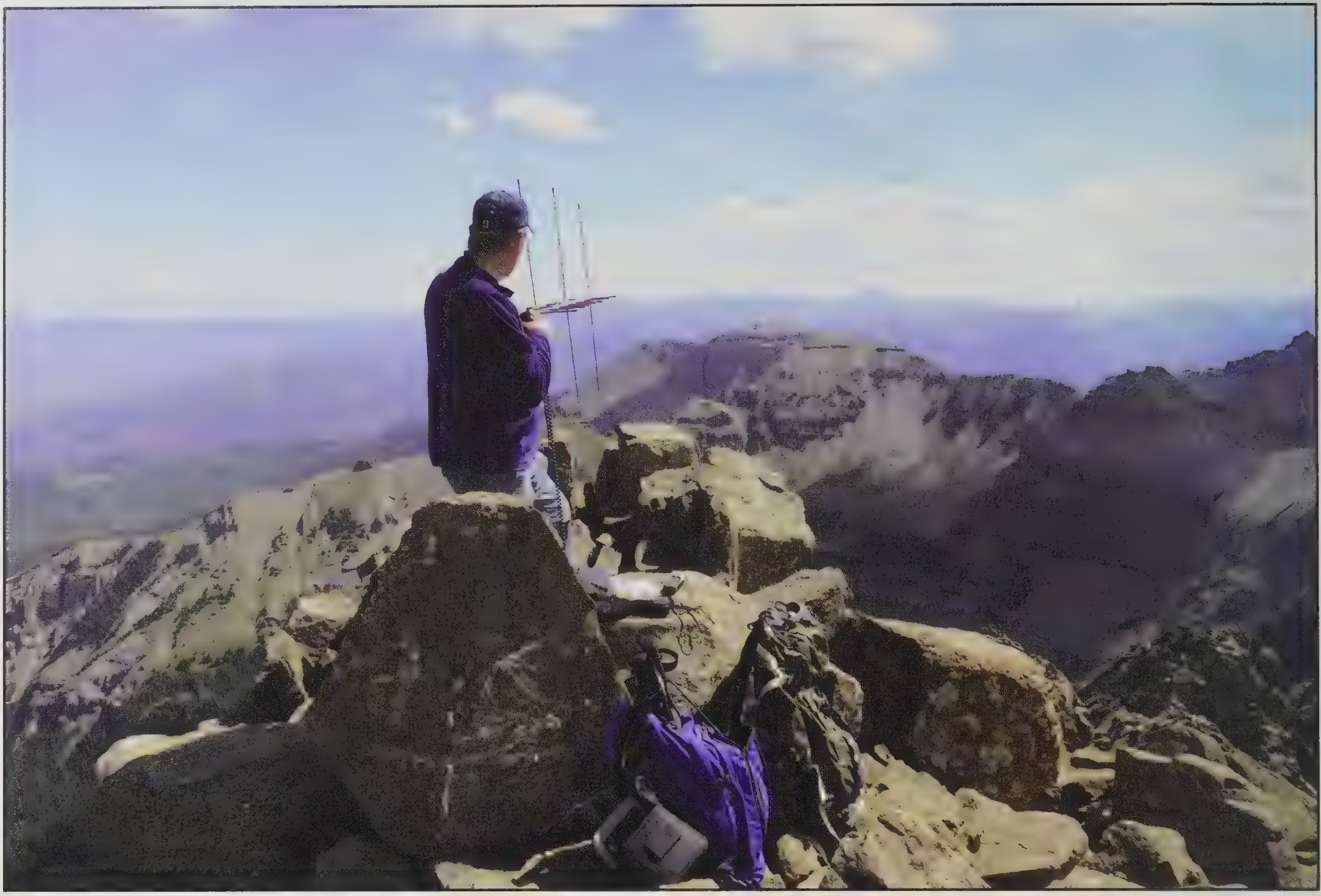


Figure 9. Bob, K0NR, uses the Arrow II Yagi antenna from the summit of Mt. Sneffels. (Photo: Joyce, K0JJW)

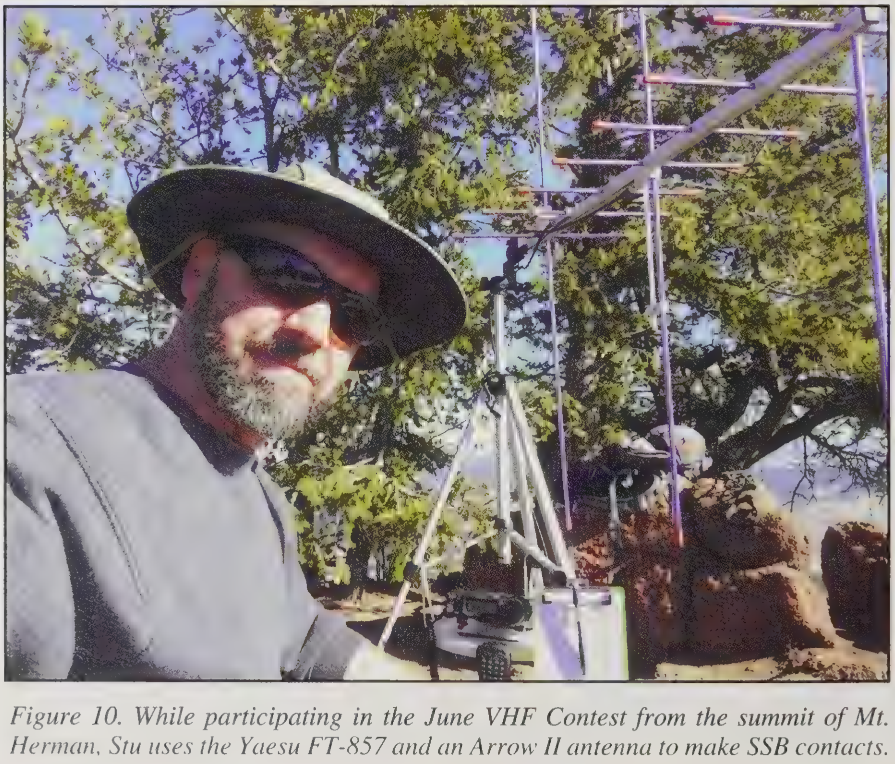


Figure 10. While participating in the June VHF Contest from the summit of Mt. Herman, Stu uses the Yaesu FT-857 and an Arrow II antenna to make SSB contacts. (Photo: Stu, W0STU)

that are easy to take hiking. Elk Antennas makes a log-periodic antenna that covers 2 meters and 70 cm (figure 8). Another popular antenna is the 2-meter/70-cm Yagi antenna made by Arrow Antennas (figure 9). These antennas are lightweight and assemble/dissemble easily, which is important to hiking radio operators.

So far, most of the SOTA VHF activity in North America is on 2 meters FM, the *utility mode*. Many hams seem to have a 2-meter HT, so tossing it in a backpack and heading out is a natural thing to do. Using my FT-817, I have made a few VHF contacts on CW and SSB. These modes are much more efficient than FM, and the station on the other end is likely to be a big weak-signal station. Nothing like a big gun station with huge antennas to help pull your QRP signal out of the noise! I also expect the use of CW and SSB to increase on VHF as SOTA becomes more popular.

APRS is a great way to share your location during a SOTA activation. Some operators post their APRS callsign on the SOTAwatch site so that chasers can track

73, Dave K1WHS
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them as they ascend the peak and operate. Again, thinking compact and portable, the HTs with built-in APRS, such as the Yaesu VX-8GR and the Kenwood TH-D72A, are popular for this activity.

VHF Contests

While the SOTA program has created a new incentive for mountaintop operating, VHF contests are still the biggest weekends for VHF activity. The ARRL VHF contests in January, June, and September use all of the bands above 50 MHz. The CQ World-Wide VHF Contest in July uses a two-band format—50 MHz and 144 MHz. Most of the contest activity is on SSB/CW, but contacts on FM are also common. Figure 10 shows a portable mountaintop station operating in a VHF contest.

The Single Operator Portable category in the ARRL contests is for portable stations operating with up to 10 watts output power. The CQ World-Wide VHF Contest has a similar category called Single Operator QRP. The CQ WW VHF Contest also has an interesting category called Hilltopper, which is the same as Single Operator QRP, but limited to 6 hours of continuous operation. As the name implies, this entry category is perfect for contesters who want to do a limited-time hilltop effort.

In an attempt to encourage FM operation in contests, the ARRL has added an FM category to the organization's VHF contests. This category is for single operators using only FM on the 50 MHz, 146 MHz, 222 MHz, and 440 MHz bands, with up to 100 watts of RF output power. It is well known that SSB is much more efficient than FM, particularly at low signal levels. On the other hand, FM equipment is much more common. The new FM category provides an opportunity for radio hams with FM gear to try out VHF contesting without competing with the more serious SSB stations.

This past year, a few VHF contest participants did a combined SOTA activation and VHF contest operation. This is a great way to combine a nice hike, activating a summit and making contacts in the contest. The key advantage of doing this on a contest weekend is that more VHF operators are on the air. In all cases, be sure you study the contest and SOTA rules to make sure your operation meets those requirements.

Tnx and 73

Thanks for taking the time to read another one of my columns on the *Utility Mode*. I always enjoy hearing from readers, so stop by my blog at <http://www.k0nr.com/blog> or drop me an e-mail.

73, Bob, K0NR

References

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SOTA North America: http://na-sota.org/
SOTA W0 Area: http://w0-sota.org/
SOTA Database: http://www.sotadata.org.uk/
SOTAwatch website: http://sotawatch.org/
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Elk Antennas: http://www.elkantennas.com/
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By Joe Moell,* K0OV

HOMING IN

Radio Direction Finding for Fun and Public Service

Using HB9CV Beams for Direction Finding

Acclaimed as one of the most scenic drives in the world is CA State Highway 1 through Big Sur on the central California seacoast. About 25 years ago, my wife April, WA6OPS, and I chose this route for our return from a trip to the San Francisco Bay area. Along the way, we took every opportunity to stop and enjoy the beautiful ocean and mountain views.

As we pulled into a vista point turnout near the famous Bixby Creek Bridge, I spotted a parked van with a four-element VHF Yagi antenna on a pole extending through a hole in the roof. This was the weekend of a southern California "All-Day" transmitter hunt, but I didn't recognize the van and I couldn't believe that someone would be looking for the hidden transmitter 270 miles from the starting point, especially since this beam was pointed toward the ocean.[1]

Upon investigating, I learned that the van's driver was a biologist at a university that was studying a colony of endangered sea otters just offshore below. Some had been outfitted with VHF radio collars that the researcher was tracking with the rooftop Yagi and also with a hand-held radio direction finding (RDF) antenna that was even more interesting. It looked like a two-element Yagi, but the feedline was connected to both elements.

Back at home, I sought more information about this compact antenna that the researcher really liked. I couldn't find it in the *ARRL Handbook* or the *ARRL Antenna Book*. Eventually, in a technical library I discovered a brief description and drawing in a *Radio Communications Handbook* published by the Radio Society of Great Britain (RSGB). It was called the HB9CV antenna in honor of Rudolf Baumgartner of Switzerland. The version in the RSGB book was an adaptation by Jan Jager, PA0TBE.

DXers may know of this antenna type from its roots in the "ZL Special" of George Prichard, ZL2OQ. It has two half-wavelength elements fed out of phase and spaced such that the element currents are 135 degrees apart. The two elements can be equal in length, but in many practical designs the front element is slightly shorter. This is not to provide parasitic effects as in the Yagi, but to improve the feedline matching and to optimize the individual element currents instead.

When oriented for vertical polarization, the directional pattern of a properly built HB9CV is heart-shaped (cardioid), with a broad front lobe of modest gain and a deep null in the rear. Its front-rear directivity is much better than a two-element Yagi of the same element spacing and its forward gain is just 1.2 dB less than a typical three-element Yagi that is more than double its size.

A direct comparison of the three antenna types is shown in figures 1 and 2. The first figure shows free-space directional patterns for horizontal polarization. Forward gain of the HB9CV is 6.3 dBi, compared to 5.9 dBi for the two-element Yagi and 7.5 dBi for the three-element Yagi. Front-to-back ratio for the HB9CV is 37 dB, compared to 23.8 dB for the three-element Yagi and only 10.7 dB for the two-element Yagi.

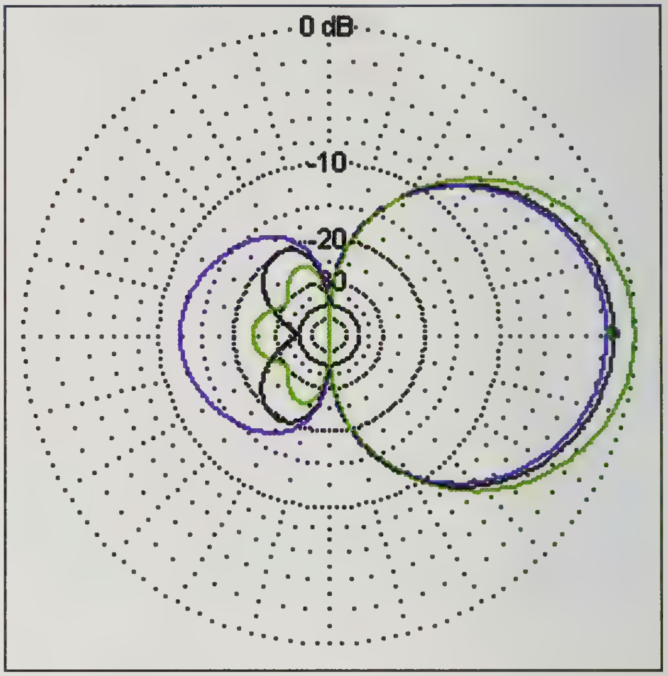

Figure 1. Polar-plot comparison of free-space directional patterns for a HB9CV phased array (black), a two-element Yagi (blue), and a three-element Yagi (green) on 2 meters, oriented for horizontal polarization. Forward lobe is toward the right.

Directional patterns for vertical polarization are shown in figure 2. Gain and front-to-back ratios are the same as figure 1 for each antenna, but the side nulls are gone, giving the HB9CV a smooth pattern with a single deep null. The 3-dB beamwidth (a measure of front-lobe sharpness) is 141.8 degrees for the HB9CV, compared to 145.0 degrees for the two-element Yagi and 110.8 degrees for the three-element Yagi.

Wide Frequency Range

Yagis are high-Q antennas with directivity that is optimum over a relatively small frequency range. For example, a Yagi that is designed and built for weak-signal work on the low end of 2 meters is not a good choice for RDF above 147 MHz. Its directivity is even worse out of band. Not so for the HB9CV. Figure 3 compares a 2-meter HB9CV with a 2-meter three-element Yagi at 161 MHz, which is more than 10 percent higher than their design frequencies. The Yagi's back lobe has 3 dB

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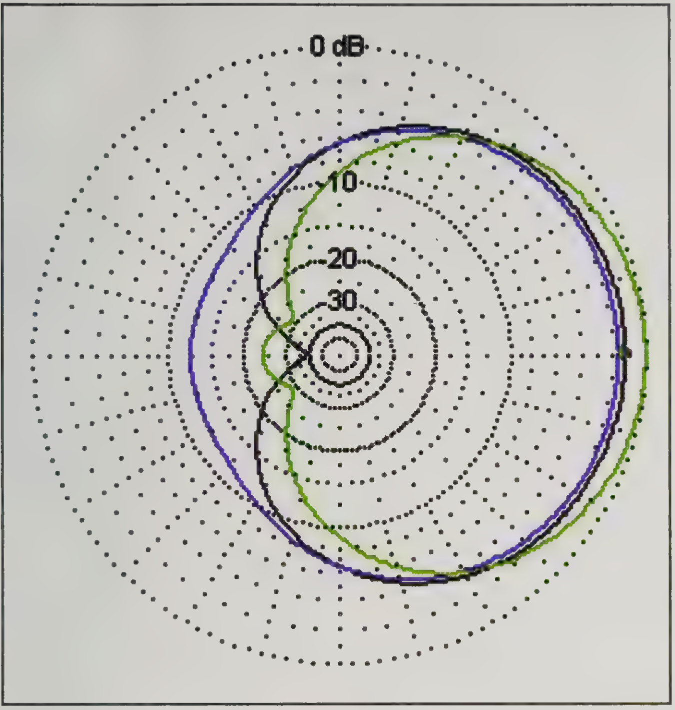


Figure 2. Comparison of free-space directional patterns for a HB9CV phased array (black), a two-element Yagi (blue), and a three-element Yagi (green) on 2 meters with vertical polarization.

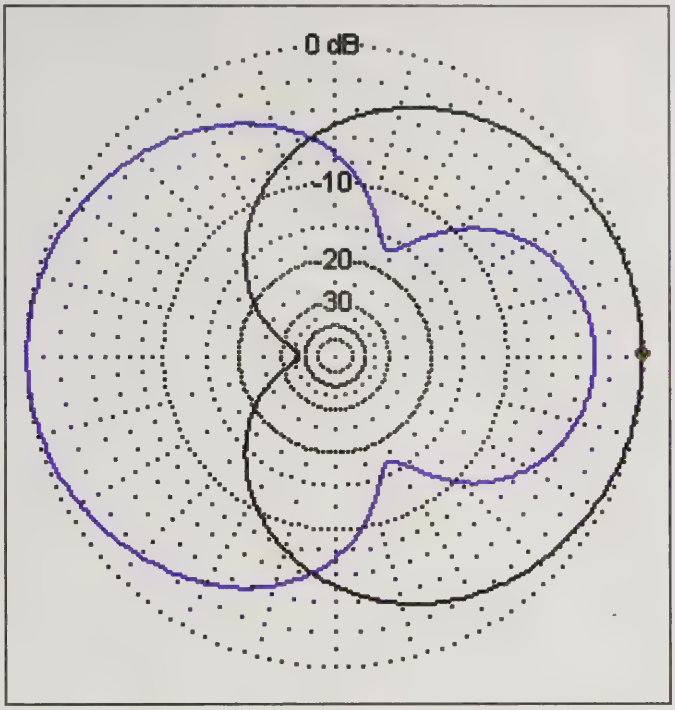


Figure 3. Comparison of free-space directional patterns for a 2-meter HB9CV phased array (black) and a 2-meter three-element Yagi (blue) operated at 161 MHz with vertical polarization to show out-of-band performance.

greater gain than its forward lobe, making it useless for RDF, but the HB9CV has good forward gain and a deep rear null.

Three-element measuring-tape Yagis with 20-inch booms are popular for on-foot 2-meter transmitter hunting, but they can be awkward for pre-teens to hold up and point toward the horizon as they walk. Unless the signal is very weak, a compact HB9CV antenna of half the Yagi's boom length is an attractive alternative for introducing young people to ham radio and transmitter hunting. The slightly greater beamwidth of the HB9CV means that bearings may not be quite as accurate, but youth will make up for that by moving faster and covering more ground as they search.

It may be tempting to seek more accurate bearings on vertically polarized signals by holding the HB9CV beam "backwards" and turning to find the sharp rear null. Try it! In a clear location with a good RF attenuator, this is likely to work well. However, if there are signal reflections (multipath), it won't.

For example, let's say that you are receiving a direct signal from the north, but there is a reflected signal 6 dB down from the east. When you turn the rear of the HB9CV north where the direct signal nulls, the side of the beam will pick up the reflected signal from the east. As the antenna is rotated a full 360 degrees, the null will be only about 10 dB lower than the peak. The 3-dB null beamwidth will be 97 degrees with this multipath instead of about 18 degrees without it.

I think that the first mobile T-hunter in the Los Angeles area to use a phased array of this type was Don Barrett, KA6DJK, of Whittier. He mounted his home-built antenna at a diagonal on a mast through the window of his vehicle to capture both horizontally and vertically polarized signals. That mounting method also minimized adverse effects to the null caused by proximity to the metal frame.

Later, a commercial HB9CV antenna for on-foot 2-meter ARDF was made and sold by Ron Graham, VK4BRG (Model ANT1/144). It was nearly identical in design to the PAØTBE design in the old RSGB handbook. In the Graham model, elements were 38$^1/2$ and 41 inches long, spaced 10 inches apart and fed gamma-style on opposite sides at 4$^3/4$ (front element) and 5$^1/4$ inches (rear element) from the boom center. This antenna is no longer manufactured, but you can build a similar version by Martin Steyer, DK7ZB, as described on the Web.[2]

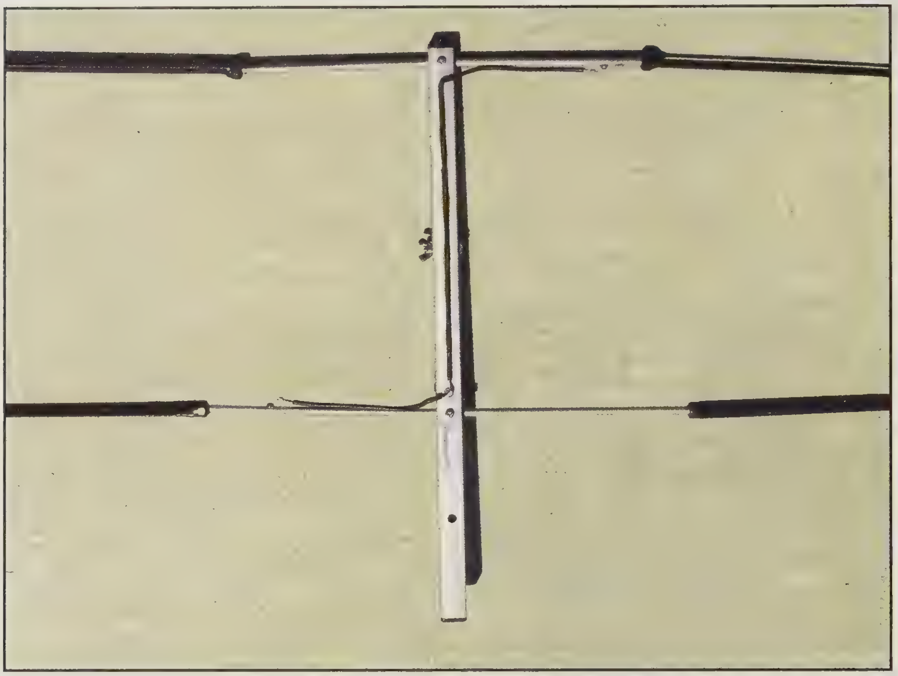
In the 1990s, the Mizuho Tsushin Company in Japan produced 2-meter ARDF sets for the growing number of competitive radio foxhunters in that country. The FRX-2000 and FRX-2001 models[3] featured a slender synthesized AM and FM receiver. It formed the boom of an antenna system that had four flexible whip antennas of equal length. Between the two whip pairs were capacitors, coupling transformers, and phasing lines that formed a loaded HB9CV beam.

After the Mizuho factory closed in 2004, these sets became highly sought after. No owner wants to part with one. Now this phased-array antenna design lives on in a new line of military RDF sets from a startup California company.

A Firestorm of RDF

Bob Miller, N6ZHZ, of Riverside, California has been an active ham radio transmitter hunter and a member of Civil Air Patrol (CAP) for over twenty years. Whenever an aircraft Emergency Locator Transmitter (ELT) or marine Emergency Position-Indicating Radio Beacon (EPIRB) is heard somewhere in southern California, chances are that Bob and his partner Cathy Livoni, KD6CYG, will be called out to locate it. The pair have found these beacons in dumpsters, at junkyards, within a transport container on a train, and inside a sailor's home. They have also tracked down interference to ELT/EPIRB frequencies caused by computers, cash registers, and the test equipment in a telephone company shop.[4]

Bob has always been on the lookout for ways to improve his RDF capabilities and to teach his methods to others in CAP. I think he was the first to track ELTs and EPIRBs with a four-element quad for 121.5 and 243.0 MHz atop his vehicle to maximize his mobile tracking range. He makes and sells fold-up three-element Yagis for the aircraft band and the 2-meter ham band.[5] He is also a stateside dealer for the popular MK4 Sniffer receiver for the aircraft and 2-meter bands by Bryan Ackerly, VK3YNG.[6]



Center section of the 11-ounce HB9CV antenna that was sold by Ron Graham, VK4BRG. The black wires along the boom feed the two elements gamma-style. Equal-length flexible element tips are screwed onto the center section to make this a safe and rugged "brush beater." (All photos by Joe Moell, KØOV)

Bob Miller, N6ZHZ, the CEO of Firestorm Emergency Services, tests a TigerStrike military RDF set with General Dynamics computer display at a park in southern California.

Noting the increasing popularity of "smart" mobile RDF systems with automatic bearing acquisition, network triangulation and GoogleEarth plotting,[7] Bob decided to come up with a similar intelligent direction finding system for on-foot use. He partnered with Canadian entrepreneur Murray Craig to form Firestorm Emergency Services, Ltd. They gathered a small team of RF and networking experts and set to work to create the TigerStrike line of VHF and UHF RDF gear.

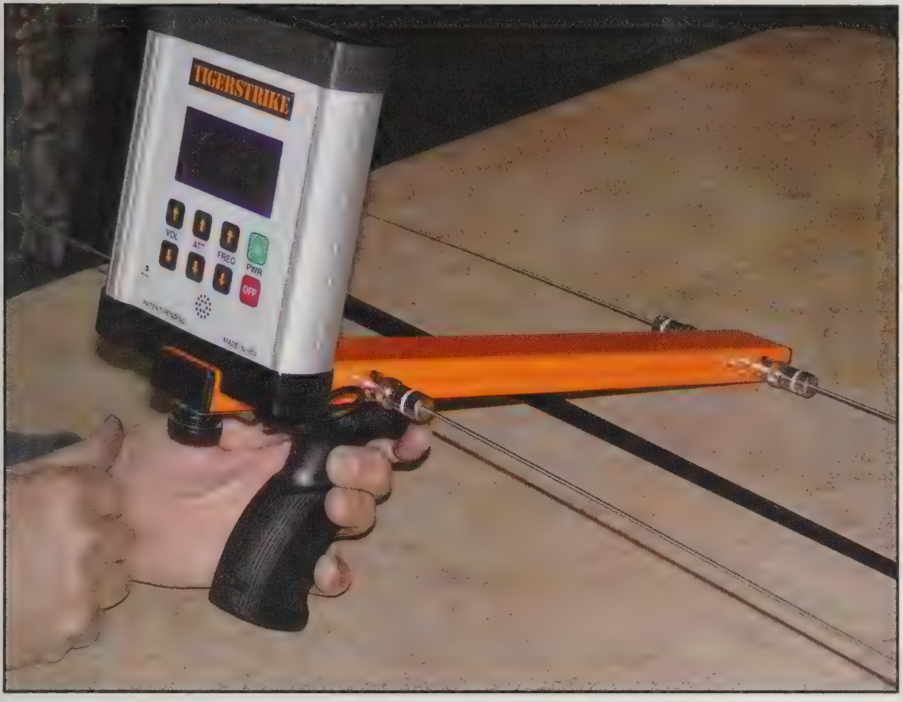
For a compact RDF antenna with good gain and wide frequency range, the team rejected beams and chose a HB9CV design that is strikingly similar to Mizuho's, including the four same-length flexible whips with BNC connectors. Antenna phasing circuitry and a low-noise high-gain RF front end are in the antenna boom. The receiver, processor, and display are mounted vertically on the rear of the boom, facing the user.

Given Bob's and Murray's long tenure in CAP, it's no surprise that ELT/EPIRB tracking was their first target market. The initial TigerStrike model had an everything-but-the-kitchen-sink list of features, including a three-axis digital compass and a Delorme high-accuracy GPS module. Cell network linking was standard, as was a Bluetooth® link to mapping software in the user's laptop nearby.

All of that technology came at a high cost. Many CAP members were purchasing their own RDF gear due to decreasing government funding, so the TigerStrike was simply unaffordable for them. The CAP market was already full of lower cost products. The networking features were of little use without a sufficient quantity of users and units in the field to form networks.

The company then made some units for the 215-MHz band used by Project Lifesaver for tracking of Alzheimer's patients.[8] Again there was strong initial interest in the user community, but the cost was prohibitive. That market had also been saturated with less costly alternatives.

Firestorm needed customers that could afford to buy its high-tech products in sufficient quantities to build effective RDF



This first-generation TigerStrike RDF set with HB9CV antenna is for tracking ELTs and EPIRBs on the 120-MHz aircraft band. The display shows frequency, bearing, compass heading, and GPS coordinates.

networks. The timing was just right. I had been receiving e-mails from military personnel in Afghanistan and elsewhere who had discovered that our enemies were using ordinary two-way radios, including ham-band transceivers, for their communications as they coordinated their attempted ambushes on our troops. The soldiers and their leaders were seeking extra-rugged RDF gear to track these transmissions. Bob and Murray jumped right on it and began working with military brass.

By then significant improvements had taken place in GPS, networking, and mapping. The team realized that these portions of their products would need to constantly be redesigned to keep up with these changes. Thus, they scrapped their custom display and networking components. Second generation TigerStrike models incorporated state-of-the-art portable computers for those functions. For military field use, they chose ultra-rugged PCs such as the General Dynamics model MR-1 GoBook.[9]

Some TigerStrike units were also made with the Trimble Nomad 900X series, which has onboard GPS and AT&T wireless.[10] With several RF front ends for various frequency ranges and several models of PCs, Firestorm now gives customers a full menu of choices for networked VHF/UHF direction finding.

Firestorm can't disclose details about its equipment's performance in military missions, but orders for more systems are coming in. Bob also tells me that his team is adding new RF front ends to the product line, including models with time-difference-of-arrival technology. I hope to report on these in an upcoming "Homing In" column.

Foxhunting Weekend and Other RDF Opportunities

CQ magazine's annual World-Wide Foxhunting Weekend is May 11–12 this year. Has your local club held its Foxhunting Weekend event yet? If the second weekend of May isn't a good one for the club members, any date in the spring will do.

CQ sponsors Foxhunting Weekend annually to encourage hams and SWLs all over the globe to experience the fun of RDF contesting in cars or on foot. More information is in my Web site[11] and in the June 2013 issue of *CQ* magazine, where you can read about last year's Foxhunting Weekend hunts in Australia and Canada plus several states, including Washington, Michigan, Illinois, and Colorado.

Transmitter hunts take place year-round where I live in sunny southern California. In other places, Foxhunting Weekend kicks off the warm-weather RDF contesting season. If my mail is any indication, it's going to be a great year, with more activity than ever. Besides lots of local hunts, there will be opportunities for you to meet and compete against foxhunters from other parts of USA and the world.

If you are attending the Dayton Hamvention®, don't miss the annual Foxhunting Forum at 11 AM on Friday, May 17 in Room 2 at the Hara Arena. It will be followed by a multi-transmitter on-foot foxhunt in a nearby park on Saturday afternoon. Last year's Hamvention® hunt was organized by Bob Frey, WA6EZV; Dick Arnett, WB4SUV; Brian DeYoung, K4BRI; and Matt Robbins, AA9YH. It took all of them to put out two dozen tiny transmitters in Sinclair Park to be sought by 18 foxhunters in 12 teams. One fox was on 80 meters and the rest were on 2 meters. An *ARRL Handbook* was the prize for winner Matt Sanderson, KC9SEM, who found 20 transmitters within the one-hour time limit.

SEA-PAC 2013, the ARRL Northwestern Division Convention in Seaside, Oregon[12] will be a good place to learn about international-rules on-foot foxhunting. Dale Hunt, WB6BYU, will give a "getting started" presentation on that topic. A demonstration hunt is being planned.

In southern California there is always a hunt at the Antennas-In-The-Park event sponsored by Fullerton Radio Club. This year it is Saturday, May 18 at Tri-City Park in Placentia. Foxhunting is often a part of other annual get-togethers such as the Duke City Hamfest and the Huntsville Hamfest. Find out if the hamfests and picnics close to you are having hunts. If not, volunteer to put one on!

The high point of 2013 for fans of international-rules foxhunting (also called radio-orienteering and ARDF) will be the Thirteenth USA ARDF Championships in the second week and weekend of October. Thickly forested courses will be in the Birkhead Mountain Wilderness near Asheboro, North Carolina. This year's ARDF championships for USA are being combined with the championships of International Amateur Radio Union (IARU) Region 2, which encompasses North and South America.

USA's national Championships are open to anyone who can run or walk through the forest for five to ten kilometers while carrying RDF gear. The optional training, sprints, and foxoring events will be October 9–11, followed by full-course competitions on 2 meters and 80 meters during the weekend of October 12–13. I will have much more information about these championships in the next "Homing In" column. Meanwhile, you can learn about the championships and about the sport of ARDF at my Web site[13] and the event Web site.[14]

Thanks, Tom

This "Homing In" column is dedicated to Tom Stewart, K3TS, who passed away last August at age 90. For many years, he was a manufacturer's representative in the Philadelphia area, but he is best known for his ham radio accomplishments. As W2TBD, he authored a classic article about hidden transmitter hunting for the September 1957 issue of *QST*. It recounted the hilarious antics of transmitter hunters in the South Jersey Radio Association, who thought nothing of putting a radio fox in a high-rise hotel room or laying hundreds of feet of coax along the bottom of a lake to a camouflaged transmitting antenna.

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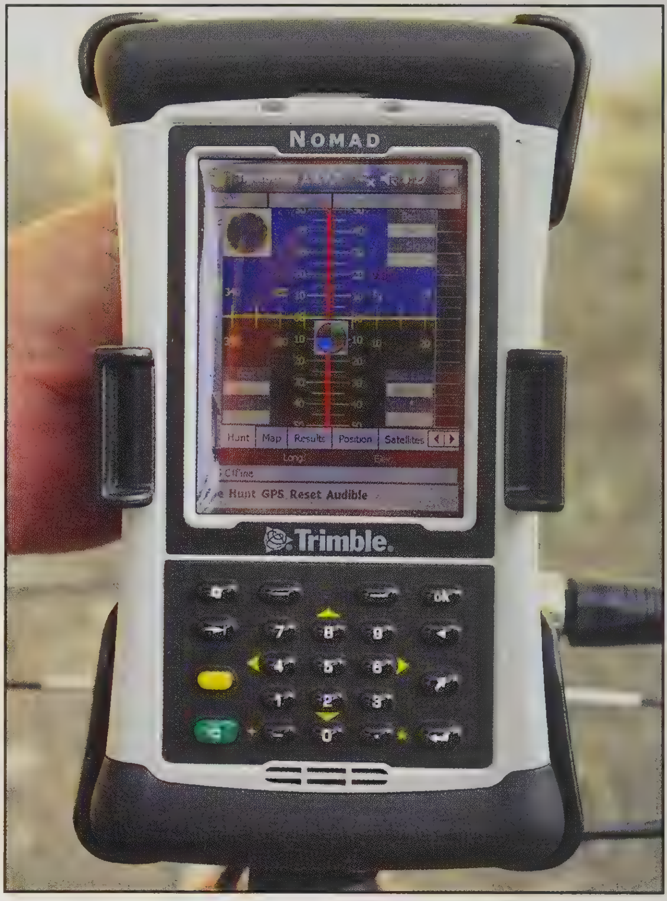

The Trimble Nomad outdoor ruggedized handheld computer as a TigerStrike RDF display unit.

These stories of RDF on 2-meter AM with wooden-frame quads, Gooney Birds, and dynamotor-powered hidden T's convinced your columnist, then a pre-teen Novice in Nebraska, that transmitter hunting might be the most fun that one could have in amateur radio. I still think so!

73, Joe, KØOV

Notes

1. But it's possible! Boundaries for the All-Day hunt are the continental USA. Transmitters have been hidden in four western states. The record distance between a hidden transmitter and the Rancho Palos Verdes starting point is 344 miles.
2. http://www.qsl.net/d/dk7zb/HB9CV/ Details-HB9CV.htm
3. http://www.qsl.net/n6qab/sniff6.htm
4 My "Homing In" column about Bob, Cathy, and the CAP is in the April 1994 issue of *73 Magazine.*
5. http://www.rdfantennas.com
6. http://www.foxhunt.com.au
7. See "Homing In" for the Winter 2012 issue of *CQ VHF*
8. My "Homing In" column in the Winter 2008 issue of *CQ VHF* tells how volunteer hams are assisting Project Lifesaver
9. http://www.gd-itronix.com/index.cfm? page=Products:MR-1
10. http://www.trimble.com/Outdoor-Rugged-Computers/nomad.aspx?dtID=features
11. CQ Worldwide Foxhunting Weekend information and forms are at http://www.homingin.com/fw13
12. http://www.seapac.org
13. http://www.homingin/com/farsnews
14. http://www.ardf.us

By Bill Brown,* WB8ELK

UP IN THE AIR

New Heights for Amateur Radio

Slow-Scan from the Edge of Space

Students from Alabama A&M University in Huntsville, Alabama flew two high-altitude balloons on April 7th. Their goal was to come up with a way to stabilize their payloads from spinning during flight. They came up with two unique ways to do this.

One student team used compressed gas through jet nozzles on each side to actively control the spin of their payload very similar to what the early astronauts used to control their motion during the first spacewalks. The other student team used R/C-style electric propellers in their design.

The APRS payloads I designed as tracking backup for these flights use an Atmel 328p processor which controls a Cypress synthesizer chip with a 200-milliwatt amplifier stage. I modified Atmel APRS code originally designed by Gary Dion, N4TXI (www.garydion.com), by porting his code to work with an Arduino-based system. This allows me to add custom telemetry fields to my APRS output and is easily modified under the popular Arduino environment. Since the main U.S. APRS calling frequency of 144.39 MHz is very busy, I decided to add the capability to switch frequencies every other transmission. The board sends a position report on 144.39 MHz and then switches to a clear channel (a nearby frequency such as 144.36 MHz, for example) and sends another short packet report followed by slower speed RTTY data. The slower RTTY speed makes it possible to decode telemetry even in weak-signal conditions and is a lot easier to DF a signal on a clear channel than on the almost constant traffic on the 144.39 MHz APRS frequency.

Photo 1. Alabama A&M University balloon payloads. (Photo by Barry Lankford N4MSJ)

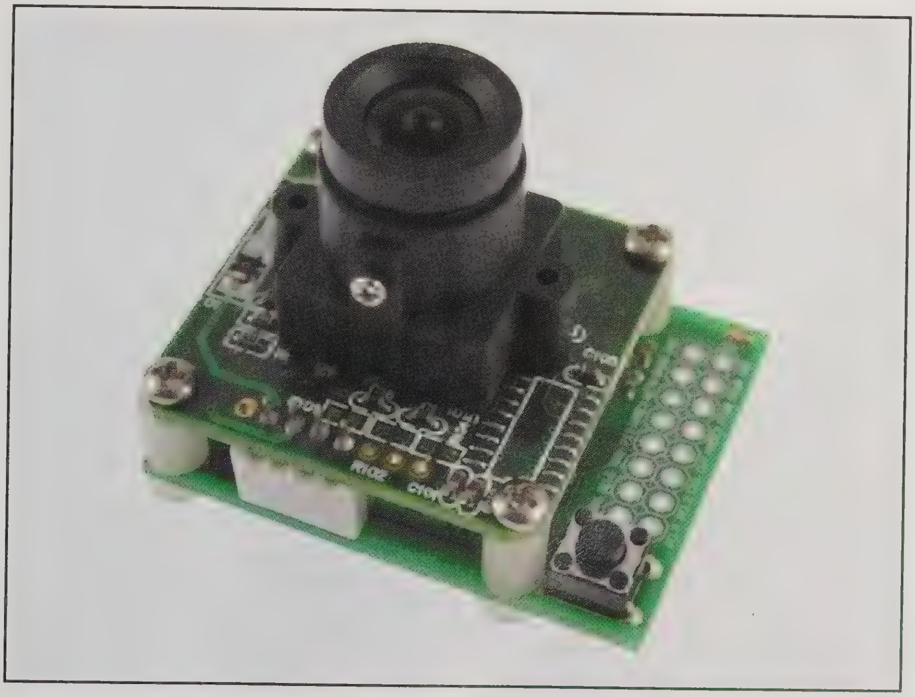

Photo 2. The Argent Data SSTVCAM board. (Photo courtesy of Scott Miller N1VG)

The SSTV CAM

It was forecast to be a beautiful spring day for the student launch, so I decided to add a live Slow-Scan Television downlink to one of the APRS tracking trans-

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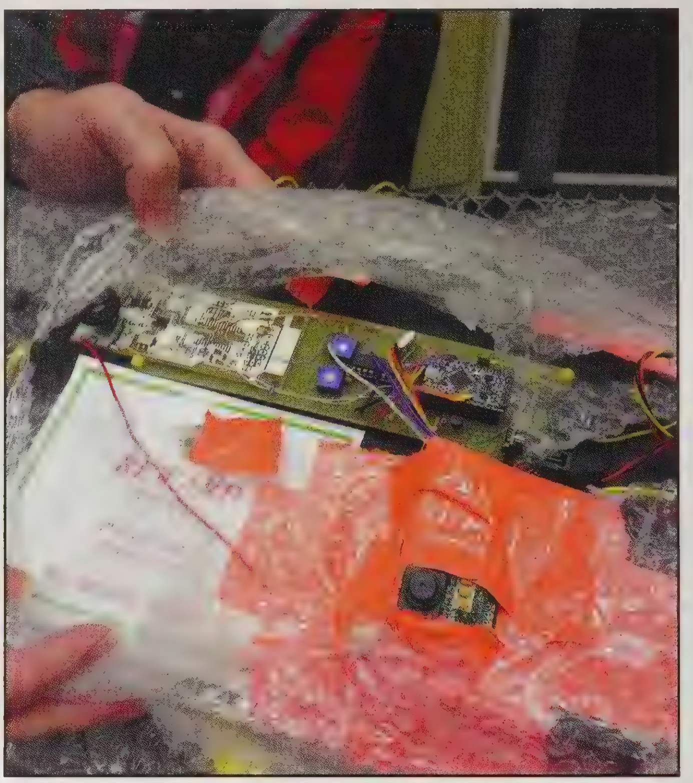

Photo 3. WB8ELK APRS payload with SSTV (real science is not possible without duct tape). (Photo by Bev Teter)

mitters. Scott Miller, N1VG, at Argent Data (www.argentdata.com) offers a very small SSTV camera board called the SSTVCAM. This uses a small TV camera module that captures a still image and serially sends the image data to the processor on the Argent Data board. The SSTVCAM is capable of sending down most of the popular SSTV modes. Although the image size is somewhat small, the quality on some of these modes is quite good. I chose the popular Scottie S2 mode which sends an image every 71 seconds. One nice feature is the ability to add a text-message line above the image field in the Scottie modes, which allowed

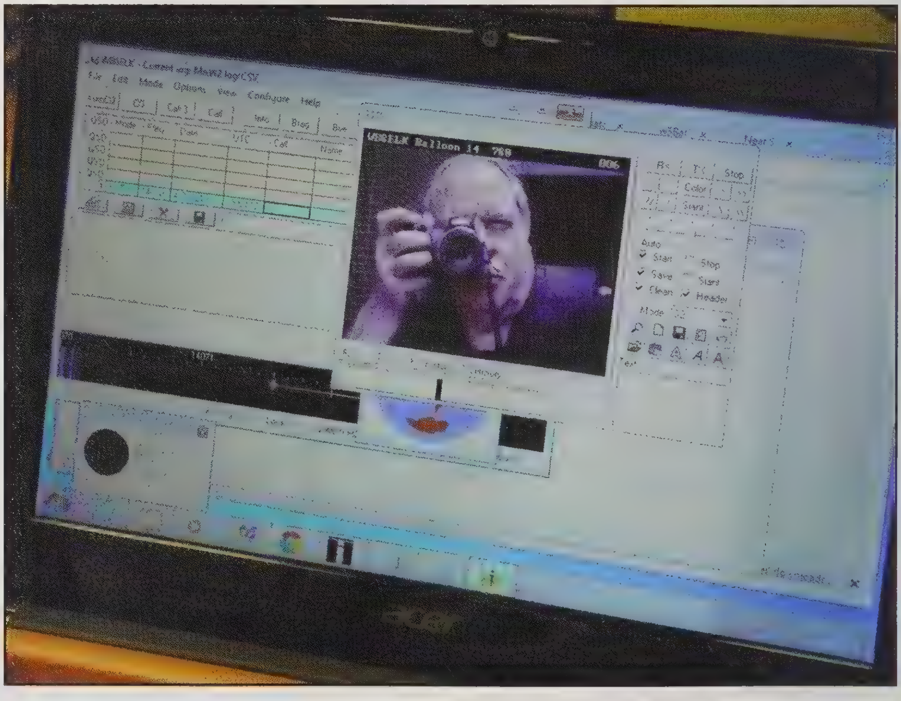

Photo 4. Using a netbook running MixW to decode the SSTV audio signal. Barry Lankford, N4MSJ, is captured taking a photo of the payload.

Photo 5. The second AA&M balloon lifts off carrying the SSTV payload. (Photo by Barry Lankford, N4MSJ)

me to display my callsign along with a sequence number and the altitude.

The SSTVCAM board was easy to interface to my board. I just set the MODE lines to configure it for Scottie S2 mode, send the text header info via a serial port pin, and then pulse the SEND line to start the SSTV transmission. I fed the audio line from the SSTV board to the APRS board and adjusted the solder jumpers on the SSTVCAM to get the proper audio level that I needed. My new live camera payload now sends APRS on 144.39 MHz, switches to a clear channel, and sends packet, then 300 baud RTTY followed by the live SSTV downlink, and then repeats that sequence during the flight. That provides a live SSTV image downlink every two minutes from a very small and lightweight module.

There are a number of programs that you can use to decode the SSTV audio signal and many of them are freeware or shareware. Some favorites that do a great job are: MMSSTV, Ham Radio Deluxe (DM780), MultiPSK, and MixW. There are even apps available for decoding with smartphones.

Although it's great to view high-resolution video recordings from a balloon flight after recovery, there is nothing like being to watch a live video downlink during flight, particularly if you have a large group of spectators at your balloon event.

Flight Day

The two A&M University balloons lifted off about 36 minutes apart and headed on nearly identical flight paths due east

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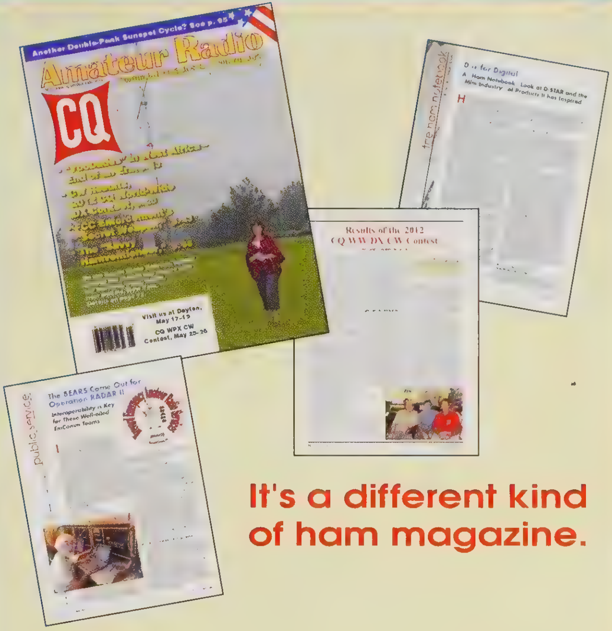

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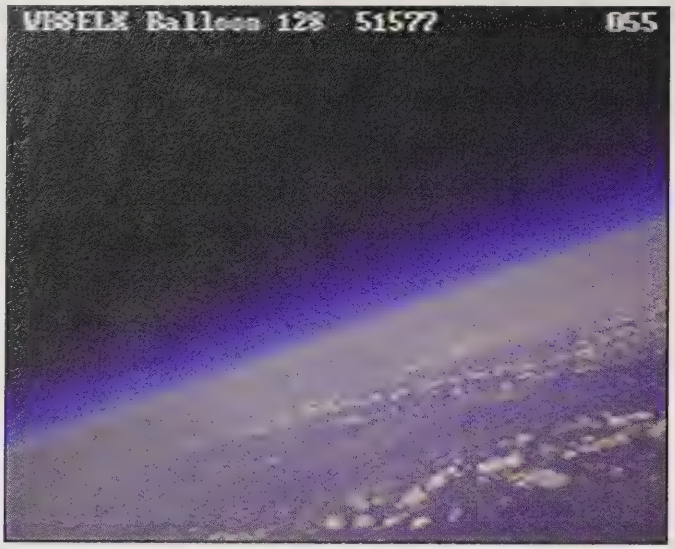

Photo 6. The SSTV image as received by Hank Cantrell, W4HTB, in Bowling Green, KY.

toward the Chattanooga area. After the balloons burst at near 90,000 feet the payloads parachuted back to Earth and landed about two miles apart in the Chickamauga, GA area. The first balloon landed on a ridge way up in a tree. Shane Wilson, N4XWC, tracked it down and after some effort managed to drag it all out of the tree. The second payload narrowly missed the trees and landed right in the middle of a cemetery for an easy recovery by Don Robinson, WA4YYM, Gary Dion, N4TXI, John Piccirillo, W4JXP, and the A&M students.

The SSTV signal worked great except that a piece of orange duct tape and bubble wrap managed to cover the camera lens during the last part of the ascent. Fortunately, just after the balloon burst, the bubble wrap and duct tape moved away from the lens and we could view spectacular images of the descent, the black sky, and the curve of the Earth, all in real-time snapshots. Beautiful images were received as far away as 320 miles by Farrell Winder, W8ZCF, in Cincinnati, Ohio. Hank Cantrell, W4HTB, in Bowling Green, KY and Todd Morgan, AL0I, in Boone, NC both had great reception from over 150 miles away. Even the chase team could view the images on their laptop computers in their vehicles.

Dayton Hamvention® SSTV Balloon

Last year we launched a balloon from the Dayton Hamvention® carrying a SSTV payload built by the ARBONET (Amateur Radio Balloons Over NorthEast Texas) balloon group. This year we will fly two SSTV payloads on separate frequencies shortly after the Friday BalloonSat Forum. The ARBONET payload will fly again, and I'll have one as well for two different views of the horizon and down at the Earth below. There will be ground stations set up in the Hamvention® that will display the live images during the flight. I hope to see you there!

73, Bill, WB8ELK

Photo 7. Easy recovery of the second AA&M payload in a Georgia cemetery. (Photo by Gary Dion, N4TXI)

By Kent Britain,* WA5VJB

ANTENNAS

Connecting the Radio to the Sky

Backpackers!

It's that time of year to get out and enjoy the outdoors. In this issue we will have some simple backpacking antennas you can use on those SOTA (Summits On The Air) tips covered by Bob Witte, KØNR, in his "FM" column elsewhere in this issue.

Figure 1 shows a simple boom. This project originally started out as an introductory project for new club members. I would drill the booms, have a good supply of element material, and bring along a ruler, wire cutters, soldering iron, glue, and some coax jumpers they could cut up. The same boom and driven element are used in all three versions of the antenna. Driven-element details are shown in figure 2, and how to attach the coax directly to the driven element is shown in figure 3. Just by cutting the other elements to length, the antenna can be used on 432 MHz for weak signal, 435 MHz for AMSAT, or 445 MHz for FM. Again, it's a pretty easy project for newbies, and they go home with something they can use immediately.

Now I am a bit limited using the same boom and hole pattern on other bands, but here is how you can easily add a two-element Yagi for 2 meters and 223 MHz for your own three-band backpacker.

2 Meters

The driven element is the same "J" configuration and goes in the same DE holes as the 400-MHz versions but is now 38 inches long. The director goes in the D2 hole and is 36.0 inches long. Again, all elements are 1/8-inch diameter material.

Element Lengths (in.)	Reflector	Driven Element	Dir. 1	Dir. 2	Dir. 3
432 MHz	13.6	Figure 2	12.5	12.25	11.8
AMSAT	13.5	Figure 2	12.5	12.25	11.75
445 MHz FM	13.25	Figure 2	12.25	12.1	11.5
146 MHz	—	38	—	36	—
223 MHz	—	24.5	24.25	—	—

Table 1. Element lengths

223 MHz

The driven element is the same "J" configuration and goes in the same DE holes as the 400-MHz versions, but is 24.5 inches long. The director is 24.25 inches long and goes in the D1 hole.

The 146- and 223-MHz versions are both simple two-element Yagis. I have covered this before, but we will repeat it here: A driven element with a director has more gain, better front to back, and is smaller than the driven element/reflector combination. You can see the driven element with director antenna projects in European publications, but rarely in the U.S. antenna books. They really do work better, but it seems they don't pass the American preference that Yagis have to have a reflector element.

Construction

For the boom I just used 1/2 by 3/4 inch wood. Almost any other wood about 1/2 inch thick works. Yes, PVC plastic can be used for your boom, but for a bunch of reasons I'm not a fan of PVC. You only need this one boom for all five versions of the antenna.

The elements are almost any rod material about 1/8 inch thick. For the reflector and director elements both bronze and aluminum welding rod work well. Hobby tubing, ground-rod wire, and even 10–12-gauge copper house wire can be used.

I do suggest taking the insulation off the house wire if you go that route. The insulation will change the resonant length of the elements 3- to 8-percent.

I can see the e-mails coming now: "But it's an insulator!"

When light travels though water, glass, plastic, etc., it travels slower than it does in free space. That is how a lens can focus, or light bends as it enters water.

Radio waves traveling through plastic, wood, and other non-conductive materials also travel slower. To be more precise, they travel at the square root of the dielectric constant, or Er. So if the plastic has an Er of 4, then the radio waves travel half as fast as in air.

Now it get a bit more complex. Call your local wire supplier and ask it for the

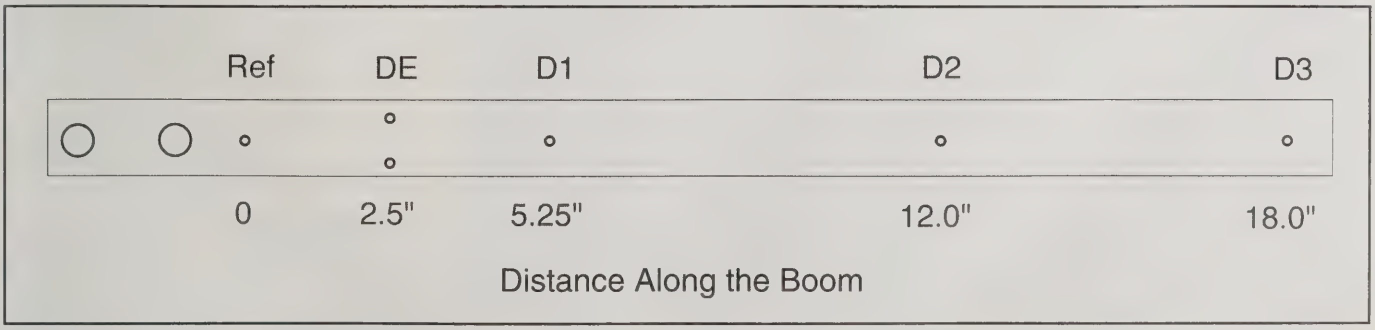

Figure 1. A simple boom

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*1626 Vineyard, Grand Prairie, TX 75052
e-mail: <wa5vjb@cq-vhf.com>

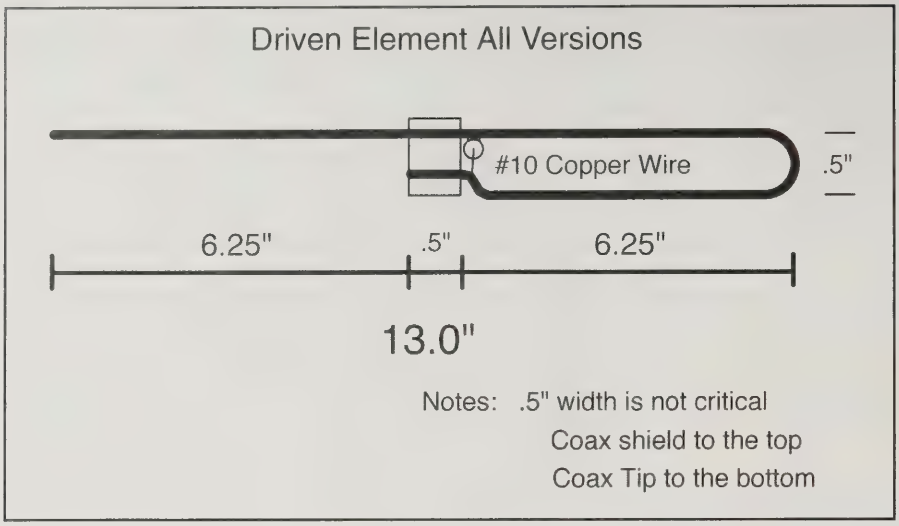
Driven Element All Versions
#10 Copper Wire
.5"
6.25"
.5"
6.25"
13.0"
Notes: .5" width is not critical
Coax shield to the top
Coax Tip to the bottom

Figure 2 Coax attachment

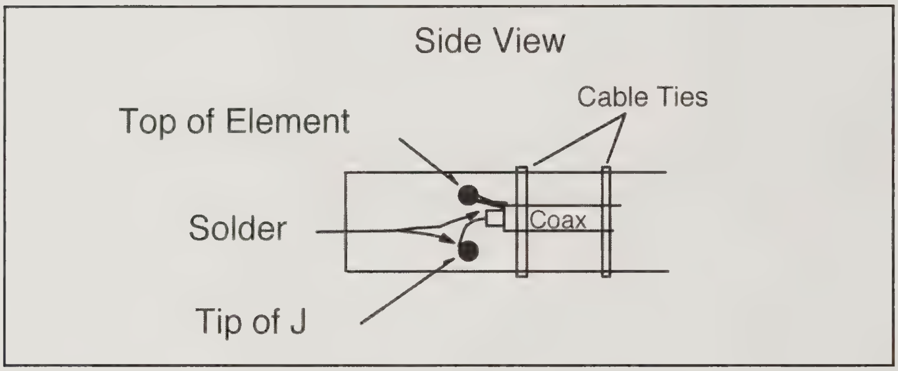
Side View
Cable Ties
Top of Element
Solder
Coax
Tip of J

Figure 3 Driven-element dimensions for all 400-MHz versions

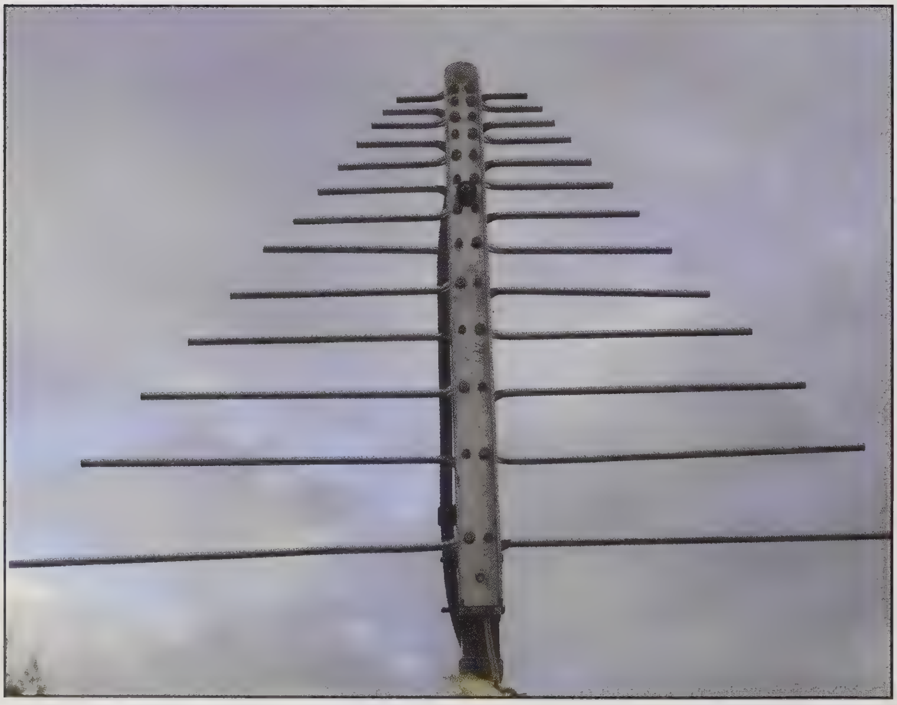

Photo A. Log periodic as the budding PhD thinks it should be mounted

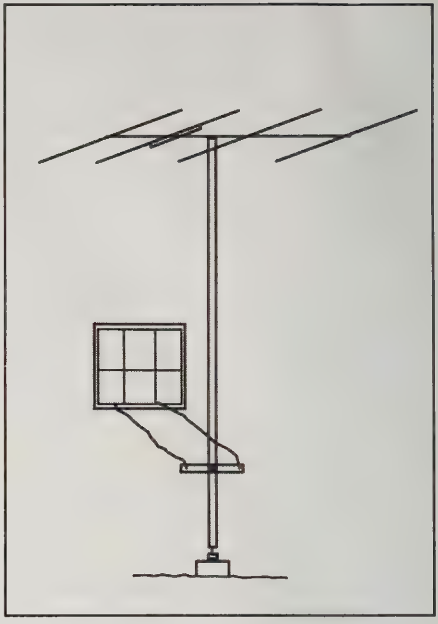

Figure 4. Leroy's 6-meter beam

dielectric constant of its wire insulation. Ready for a deer in the headlights response? If you are very lucky, or look up the material on the Web, that Er value is typical made at 10 kHz, not 145 or 445 MHz! And the insulation is a pretty thin coating, so not all of the RF energy is in the plastic.

Ok, enough of my ADHD and back to the elements. I suggest making the driven element from bronze welding rod, #10 copper wire, or copper/brass hobby tubing. These are much easier to which to solder the coax.

There are several ways to hold the element in place:

One veteran backpacker would use soft wire for all the elements glued in place and just wad up the whole thing and stick it in his backpack. He said the antennas were good for nearly a dozen waddings before he needed to build another one.

Small bits of rubber tubing, rubber bands, and even tape will work for a while. One reader likes to use those plastic thumb locks used to secure tent and backpack cords to hold the element in place. It certainly is easy enough to take them apart later. Again, this quick and easy 4332/435/445-MHz beam makes a great hands-on club project for new hams.

Log Periodics

I want to cover this topic because it keeps coming up again and again. I just had a spirited debate with a lad working on his PhD project who firmly believed

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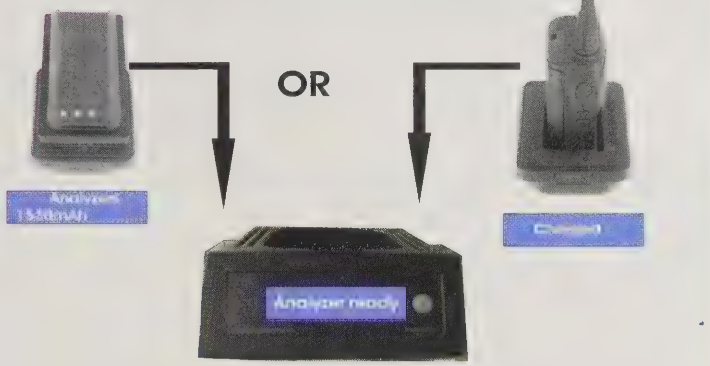

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that mounting his log periodic as shown in photo A was the best way. That's right—point straight up with the flat side to the other station. This way it catches more signal! It's an interesting concept, but nope, maximum signal is off the pointed end as in photo B.

Leroy's 6-meter Beam

This is an Armstrong rotator. Leroy May, W5AJG/W5HN, used the arrangement in figure 4 on his 6-meter beams for many, many years. Leroy would tune in a 6-meter signal, run over to the window, pull on the ropes, peak the signal, and then slam the window down on the ropes to hold the beam in position. A quick jerk could get him beyond 180 degrees of swing. He earned the WAC and WAS awards with this system. The bottom bearing was from the rear axle of a Model T Ford; the mast was 25–30 feet of 4" × 4" lumber and then the beam. There was another bearing at the edge of his room, but I am afraid that I can't remember just how he had used it. Leroy was quite the VHF operator. He came very close to WAS on our 5-meter band before the war closed it down.

Future Projects

Yes, I still have that second 20-element 432-MHz Cheap Yagi under construction. With the second antenna, I can show combinations of phasing harness and mounting points such that the antennas can be mounted for vertical, horizontal, right-hand circular or left-hand circular polarization. Also, I am collecting parts for a pair of 1296-MHz long Cheap Yagis for the next time they fire up Arecibo off the moon.

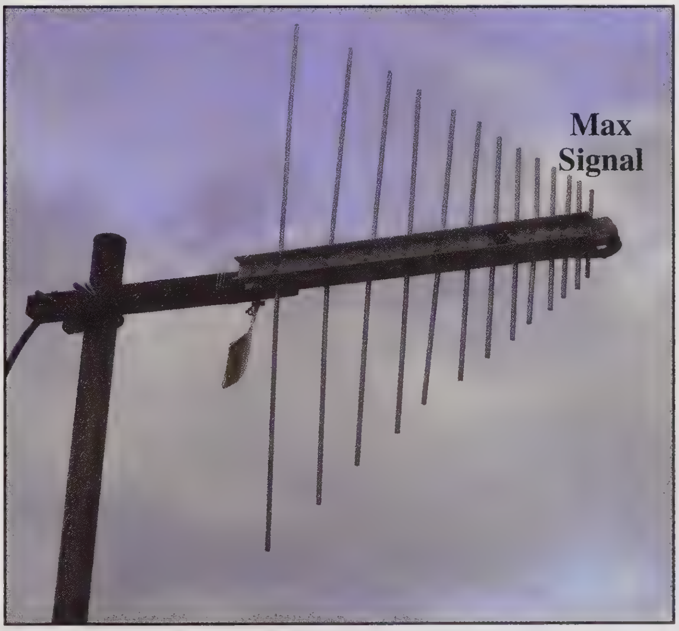

Photo B. Correct way to mount a log periodic

As always, we welcome questions and column suggestions from our readers. An e-mail to <WA5VJB@cq-VHF.com>, or snail mail to the QRZ.com address for WA5VJB will also work. And I have even more antenna construction projects at <http://www.wa5vjb.com> in the Reference section.

73, Kent, WA5VJB

Announcing:

The 2013 CQ World-Wide VHF Contest

Starts: 1800 UTC Saturday, July 20, 2013
Ends: 2100 UTC Sunday, July 21, 2013

The 2013 rules reflect changes in the log submission deadline and the results publication date that have been implemented by CQ. In order to be considered for an award, your log must be received by the robot or postmarked by 2359 UTC on August 4, 2013. Logs received after the deadline will be listed in the results but will not be eligible for an award. Extensions may be granted by the director for a valid reason if you contact the director before the deadline.

I. Contest Period: 27 hours for all stations, all categories. Operate any portion of the contest period you wish. (Note: Exception for QRP Hilltopper.)

II. Objectives: The objectives of this contest are for amateurs around the world to contact as many amateurs as possible in the contest period, to promote VHF, to allow VHF operators the opportunity to experience the enhanced propagation available at this time of year, and for interested amateurs to collect VHF Maidenhead grid locators for awards credits.

III. Bands: All authorized amateur radio frequencies on 50 MHz (6 meters) and 144 MHz (2 meters) may be used as authorized by local law and license class.

IV. Assistance: There are three types of QSO alerting assistance:

1. Passive is defined as any technology that provides callsign and frequency information of potential new contacts to the operator, not initiated by the entrant. It includes, but is not limited to: The DX Cluster, spotting nets, packet and web clusters, Skimmer, and the like.

2. Active involves the direct initiation of QSO alerting information by—and with the direct participation of—the entrant to benefit the entrant's score. It includes, but is not limited to, self-spotting or by stealth (such as asking other stations to spot you). **Active QSO alerting** assistance is permitted only by stations attempting digital EME or digital meteor-scatter contacts. Stations calling CQ using such modes are limited to spotting callsign, frequency, and sequence only. Caution: To ensure strict compliance with these rules, the adjudication process will include review of real-time and archived transcripts from websites used to coordinate active alerting data during the contest period.

3. Interactive includes any two-way conversation (or variation thereof) between stations to effect a QSO. This includes use of the telephone, and website posts providing information beyond that of callsign, frequency, and sequence. **Interactive QSO alerting** is prohibited for all categories during the contest period.

V. Categories of Competition: For all categories: Transmitters and receivers must be located within a 500-meter diameter circle or within the property limits of the station licensee's address, whichever is greater.

1. Single Op—All Band. Only one signal allowed at any one time; the operator may change bands at any time.

2. Single Op—Single Band. Only one signal allowed at any one time.

3. Single-Op All-Band QRP. There are no location restrictions – home or portable – for stations running 10 watts output or less.

4. Hilltopper. This is a single-op QRP **portable** category for an all-band entry limited in time to a **maximum of 6 continuous hours**. Backpackers and portables who do not want to devote resources and time to the full contest period are encouraged to participate, especially to activate rare grids. Any power source is acceptable.

5. Rover. A Rover station is one manned by no more than two operators, travels to more than one grid location, and signs "Rover" or "/R" with no more than one callsign.

6. Multi-Op. A multi-op station is one with two or more operators and may operate 6 and 2 meters simultaneously with only one signal per band.

Stations in any category, except Rover and QRP Hilltopper, may operate from any single location, home or portable.

VI. Exchange: Callsign and Maidenhead grid locator (4 characters, e.g., EM15). Signal reports are optional and should not be included in the log entry.

VII. Multipliers: The multiplier is the number of different grid locators worked per band. A "grid locator" is counted once per band. Exception: The rover who moves into a new grid locator may count the same grid locator more than once per band as long as the rover is himself or herself in a new grid locator location. Such change in location must be clearly indicated in the rover's log.

1. A rover station becomes a new QSO to the stations working him or her when that rover changes grid locator.

2. The grid locator is the four character Maidenhead grid (e.g. EM15).

VIII. Scoring: One (1) point per QSO on 50 MHz and two (2) points per QSO on 144 MHz. Work stations once per band, regardless of mode. Multiply total QSO points times total number of grid locators (GL) worked.

Rovers: For each new grid locator visited, contacts and grid locators count as new. Final Rover score is the sum of contact points made from each grid locator times the sum of all grid locators worked from all grids visited.

Example 1. K1GX works stations as follows:

50 QSOs (50 × 1 = 50) and 25 GLs (25 multipliers) on 50 MHz

35 QSOs (35 × 2 = 70) and 8 GLs (8 multipliers) on 144 MHz

K1GX has 120 QSO points (50 + 70 = 120) × 33 multipliers (25 + 8 = 33) = 3,960 total points.

Example 2. W9FS/R works stations as follows:

From EN52: 50 QSOs (50 × 1 = 50) and 25 GLs (25 multipliers) on 50 MHz

From EN52: 40 QSOs (40 × 2 = 80) and 10 GLs (10 multipliers) on 144 MHz

From EN51: 60 QSOs (60 × 1 = 60) and 30 GLs (30 multipliers) on 50 MHz

From EN51: 20 QSOs (20 × 2 = 40) and 5 GLs (5 multipliers) on 144 MHz

W9FS/R has 230 QSO points (50 + 80 + 60 + 40) × 70 multipliers (25 + 10 + 30 + 5) = 16,100 total points

IX. Awards: Certificates suitable for framing will be awarded to the top-scoring stations in each category in each country. Certificates may also be awarded to other top-scoring stations that show outstanding contest effort. Certificates will be awarded to top-scoring stations in each category in geographic areas where warranted.

Geographic areas include states (U.S.), provinces (Canada), and countries, and may also be extended to include other subdivisions as justified by competitive entries. U.S. rover certificates are issued on a regional basis.

Plaques again will be awarded to the highest scoring stations. They are offered in various categories on a sponsored basis. Clubs and individual plaque donors are sought and may find information on how to sponsor a CQ WW VHF Contest plaque at <http://www.cqww-vhf.com/plaques.htm>.

X. Club Competition: Credit your club for aggregate club score. See <http://www.cqwww.com/clubnames.htm> for a list of registered clubs. Follow directions for registering your club if not already registered.

XI. Miscellaneous: An operator may sign only one callsign during the contest. This means that an operator cannot generate QSOs by first signing his callsign, then signing his daughter's callsign, even though both callsigns are assigned to the same location.

A station located exactly on a dividing line of a grid locator must choose only one grid locator from which to operate for exchange purposes.

A different multiplier cannot be given out without moving the complete station at least 100 meters.

Making or soliciting QSOs on the national simplex frequency, 146.52 MHz, or your country's designated national simplex frequency, or immediately adjacent guard frequencies, is prohibited. Use of commonly recognized repeater frequencies is prohibited. Recognized FM simplex frequencies such as 146.49, .55, and .58, and local-option simplex channels may be used for contest purposes.

Aeronautical mobile contacts do not count.

Contestants should respect use of the DX window, 50.100–50.125 MHz, for intercontinental QSOs only.

UTC is the required logging time.

XII. Declaration: Your submission of a log entry affirms that: (1) you have abided by all the rules of the contest as well as those of your country's licensing authority; (2) you accept any decisions made regarding your entry by the contest's adjudication process which are official and final.

XIII. Log Submissions: Log entries must be submitted by **August 4, 2013** to be eligible for awards. Submit your electronic log in the Cabrillo format created by all major logging programs. Send via e-mail attachment to <cqvhf@cqww-vhf.com>. Subject line: Callsign [the call used in the contest] only.

Entrants are reminded to be sure their log indicates their grid location. For USA/VE stations operating away from their home address, be sure to indicate the state or province location of operation. If you have a problem submitting your log please contact <help@cqww-vhf.com> for assistance.

It is strongly recommended that paper logs be entered on-line for automatic Cabrillo submission. Click on the "Web Form for Typing in Paper Logs" link on the contest website at <http://www.cqww-vhf.com>. Computer-generated logs must be e-submitted. Callsigns of electronic logs received are posted and updated daily on the website.

For those without web access, paper logs may be mailed to: Paper Logs, P.O. Box 481, New Carlisle, OH 45344. Questions may be sent to <help@cqww-vhf.com>.

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By Keith Pugh,* W5IU

SATELLITES

Artificially Propagating Signals Through Space

What to do While Waiting for the Next Satellite or the Next Band Opening

Once bitten by the "Satellite Bug," most of us have invested quite a bit in equipment for working satellites – especially if you geared up for the High Earth Orbit (HEO) satellites several years ago. These are no longer available and we are in a temporary "slump" in other satellite activities. Therefore, are there alternate uses for this equipment? You betcha!

This can work two ways: working other opportunities between satellite passes and working satellites to fill gaps in other activities.

Equipment Assumptions

Minimal Equipment—FM Only. If you are just equipped to work the FM "Easy Sats," the list of options is shorter, but there are alternate things you can do. The equipment assumptions here are FM transceiver capabilities on VHF and UHF, hand-held directive antenna(s), portability, and basic computer access.

1. Public Service Communications. This is a very important aspect of amateur radio. Work with your local radio club; Radio Amateur Civil Emergency Service (RACES); Amateur Radio Emergency Service (ARES); National Weather Service; Red Cross; Salvation Army; or other groups to provide Sky Warn coverage, emergency communications, and communications for public-service events such as runs, walks, bicycle rides, parades, etc. Participation in public-service events is good training for working in real emergency situations.

2. Fox Hunting (Radio Location). This activity is growing as a competitive sport worldwide. Your handheld directive antennas along with your radios and some basic training and judgment will equip you for this activity. This can be a purely competitive effort for sport or the capability can be used to locate interference sources, missing aircraft, and other useful radio location exercises.

3. If you also have packet radio capability, you are equipped to do basic data and message handling, and to participate in the Automatic Packet Reporting System (APRS). When used in conjunction with GPS, this is commonly known as the Automatic Position Reporting System. This capability can be used in conjunction with all of the other activities.

Moderate Equipment—SSB/CW for Linear Transponders. This level of equipment opens up the world of "weak-signal's VHF, UHF, and microwaves. Equipment assumptions here are multimode transceivers on VHF and UHF (or for use as an IF for a microwave band), moderate amounts of power, moderate gain antennas with Az-El positioning, mast-mounted receive pre-amplifiers, access to transverters for microwave bands, and additional computing power for control and processing. Here are some of the possibilities:

1. Watch for band openings on all of the bands you are capable of operating. Talk to your old friends and make new ones.

2. Watch for openings that are dependent upon different kinds of propagation.

a. Line of sight. Nothing new. Point and talk. Stations must be line-of-sight with each other; however, a slight amount of "bending" can sometimes occur.

b. Temperature inversions. Watch for weather patterns that favor formation of these inversions and the "RF ducts" which may form as a result of them. Long distances are possible through these ducts, which act as waveguides bending the signal path around the Earth. My "personal best" for this mode was a contact between Fort Worth, TX, and Orlando, FL, as a result of a 70-cm duct that formed between the two locations. Great signals occur during the time the duct is present. Minimal power and gain are required with a good duct present. Of course, this could also work with your FM rig. You may begin to hear distant repeaters as a clue.

c. Tropospheric Scatter. You and your buddies at moderate (but beyond line-of-sight) distances apart can aim your antennas at a common part of the sky above line-of-sight and, with enough ERP (Effective Radiated Power), establish contact. This is not too popular in the Amateur Radio Service due to the amounts of ERP required.

d. Ionospheric Scatter. Similar to tropospheric scatter except the ionosphere is the media and its altitude is higher, making the possible distances greater. With enough ERP it is possible to create your own ionization to some degree. At suitable frequencies and with suitable conditions this can be a player in the Amateur Radio Service. This mode can be a player most often at HF. It happens at VHF and UHF, but is rare.

e. Meteor Scatter. Meteors create a plasma trail that can reflect RF. If there are enough of these plasma trails, it is possible to carry on a QSO by pointing at the meteors as they go "whizzing by." This happens rather quickly and the contacts are very short, favoring CW or Digital Data. This mode happens most often on the 6-meter band and during meteor showers (times that produce greatest numbers of meteors).

f. Aurora. At times of significant geomagnetic disturbance aurora can form. The plasma that creates the visible aurora can reflect RF energy. At such times it is possible for many operators to point their antennas toward the aurora (usually to the north in the Northern Hemisphere) and talk to each other via the reflections. This type of reflection produces distinctive sounds due to the motion of the plasma and the resulting Doppler effects. CW at 2 meters sounds like the old "spark gap rigs." Voice can be very hard to understand. At lower frequencies, these effects are not as great, since Doppler effects are greater at higher frequencies. With the advent of more satellites monitoring the Sun, we are now able to predict geomagnetic disturbances more readily. There are even smartphone apps that will enable you to monitor these predictions more readily.

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g. Conventional Moonbounce (OSCAR Zero). Years ago the amount of ERP necessary for successful moonbounce activity was excessive and only a very few amateur radio operators could participate. Occasionally, large radio telescopes are "put on the Moon" and the average satellite operator can work these stations with their satellite rig. I made a two-way QSO on CW with VE3ONT on 70 cm several years ago during such an opportunity. Others were able to do this even on 2 meters during the following weekend. More recently, a group of operators put the 1000-foot dish at Arecibo, PR, on 70 cm. I was able to hear this activity in all of its modes with my satellite station but did not make a two way. Others did more with less. Single long Yagi stations with 100 watts and a good receiver can now make successful contacts with big stations at times of "Earth gain," which happens at Sunup or Sundown.

h. Digital Moonbounce. Technology has now improved to the point to where it is possible to do moonbounce with a moderate station on a regular basis using digital modes with the help of computer processing. This is most often done with the aid of a program called WSJT, written by Joe Taylor, K1JT. Other versions of this program have been tailored to enhance other weak-signal propagation modes.

3. Contesting. Work the many VHF, UHF, and microwave contests that are now available. Do this either by yourself or part of a club effort.

4. Mount some of your equipment in a vehicle and become a "Rover" to enhance contesting or simply to provide new grids for your friends like we do through the satellites. This requires more effort and dedication than being a satellite Rover, since more bands are available and signals are generally weaker.

Summary

These are just some of the possibilities. Use your imagination and your equipment to experiment and find new uses and modes of propagation. The pages of this magazine are an excellent place to learn more about all of the VHF and UHF activities.

Don't let all of your capabilities go to waste. Use your equipment in all of its modes and on all of its frequencies. Read about all of the possibilities through the articles and columns in this magazine and the many other venues that are available. Attend the excellent conferences and symposiums dedicated to work in these areas. Don't just look at the equipment, listen to the talks and talk to the people. Of course, there are many talks and forums at the Dayton Hamvention®, but also this year consider attending Central States VHF Conference in the Chicago suburbs (Elk Grove Village, IL) July 25–27; Microwave Update at Morehead State University, Morehead, KY, October 18–19; and the AMSAT Space Symposium November 1–3 in Houston, TX. I also try to get to the AMSAT UK Space Colloquium whenever possible.

I've been attending these functions since 1983 and never tire of them. I don't understand everything I hear, but a little bit rubs off each time: "If you're not careful, you learn something every day (and at every conference)."

Please continue to support AMSAT's plans for the future of amateur radio satellites. There are new things happening all the time. Refer to the newly redesigned AMSAT web page at <http://www.amsat.org> for details. Follow the projects and progress of AMSAT-UK at <http://www.uk.amsat.org/>.

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'Til next time! 73, Keith, W5IU

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By James Duffey,* KK6MC

BEGINNER'S GUIDE

All you need to know but were afraid to ask . . .

It's Almost Summertime and the VHF Bands are Active

Summertime, which will be upon us not far in the future in the Northern Hemisphere, is a busy season for the VHFer. Sporadic-*E* reigns supreme on 6 meters with an occasional excursion to higher frequencies, and it is VHF/UHF contest season. Both bring with them increased VHF activity and the opportunity to add to one's grid total. Now is the time to get ready for both.

The good summer weather offers a chance to do some antenna work outside without inclement weather. You'll be grateful you did the work during the nice summer weather when winter comes around again. Nothing will improve your station like a better, higher antenna fed with lower loss feedline.

Sporadic-E

Sporadic-*E* is a good part of what makes the "Magic Band" magic. I covered sporadic-*E* propagation in detail in my column in the Spring 2012 issue of *CQ VHF* magazine. For more details on sporadic-*E* propagation look there *(as well as in the "VHF Propagation" column by NW7US—ed.)* I will review some of the features of sporadic-*E* propagation here as a refresher, though.

Sporadic-*E* propagation is the result of ionized patches forming in the ionospheric *E*-layer. Ions present in the *E*-layer get concentrated by wind shear and form patches of sufficient density so that they can reflect radio signals. Due to the wind shear nature of their creation, the formation of these clouds is difficult to predict with good accuracy, hence the name *sporadic*. There are good statistical indicators of when sporadic-*E* will occur so that you can look for it at times when it is most likely to be evident.

Very high ion density can occur in the ionized patch, so reflection can be efficient. Thus, during a good opening, signals are strong and communication is possible with little power. When the band is open, sporadic-*E* can be a good friend to the VHF QRPer.

The *E*-layer supports propagation out to 1300 miles or so, and most of your contacts via the sporadic-*E* mode will be within that distance. Often, though, you will get double-hop sporadic-*E*, where your signal will reflect off one ionized patch, then off the ground, then off another ionized patch. This can double your effective skip distance. Occasionally three or more ionized patches can participate in propagation, but this is rare.

Sporadic-*E* is most likely to occur in the mid-morning and early evening, so those are good times to check the calling frequency for activity in the summer. Sporadic-*E* activity in the morning is often an indicator of sporadic-*E* in the evening, so check the bands in the evening for more activity if you have worked stations in the morning.

Sporadic-*E* on 2 meters is much rarer than on 6 meters, but it can occur several times during the summer. Look for *E*-skip on 2 meters when the skip gets short, say less than 1300 miles, on 6 meters. These openings are typically short, so you need to be quick to catch an opening.

Obviously, it helps to have some heads up as to when sporadic-*E* will occur. The highest frequency that will support propagation on sporadic-*E* usually increases as the ionized patch forms. So, lower frequencies such as 10 meters will have propagation before the higher bands, such as 6 meters, have propagation. It has traditionally been the practice to monitor the 10-meter ham band for the likelihood of propagation on 6, and the FM band for the likelihood propagation on 2. The pager band just below the 6-meter band was also useful to monitor, but pager activity has largely decreased. Today, most active 6-meter operators check DX Sherlock on the web for signs of activity: <http://www.dxmaps.com/spots/map.php?Lan=E&Frec=50&ML=M&Map=W2LN&DXC=N&HF=N&GL=N>.

This is a quite useful tool, showing QSOs that have been made over the last half hour, as well as the calculated position of the ionized patch responsible for the QSO, and an estimated mode of propagation. One can even receive e-mail alerts when propagation occurs.

Nothing substitutes for activity, particularly listening, though. Monitor the calling frequency as well as the beacon band for signs of propagation. Don't neglect the CW portion of the band. Stations often show up there before they do on phone. Occasionally call CQ. Even with the internet alerts, someone needs to be on to make that initial QSO so it can be posted.

Contests

The sporadic-*E* season and the increased activity it brings are used as an opportunity by several organizations to sponsor VHF contests in the summer. Contests are a good way to build your operating skills, evaluate your station performance, and increase your grid total.

I covered how to operate a contest in my *CQ VHF* Winter 2012 column, so I won't repeat that information here. You should make an effort to read the rules and familiarize yourself with the exchange before entering a contest. If possible, prepare and submit a log after you have finished the contest; contest sponsors need the feedback, and deadlines are important.

Here is a summary of the contests that occur in the summer:

CQ WW VHF. Starts: 1800 UTC Saturday, July 20, 2013; Ends: 2100 UTC Sunday, July 21, 2013. Rules:

---

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<http://www.cqwwvhf.com/ rules.htm>. *(See the CQ WW VHF Contest rules elsewhere in this issue.—ed.)*

This contest is for 6 meters and 2 meters only. Many contesters like that format as they do not need to worry about going away from a 6 meter opening to work the higher bands. The contest also allows single band entries, so you can concentrate only on 6 or 2 if that is your fancy. The Hilltopper category appeals to the QRP VHFer as well as those who can only afford a short time operating. The contest does occur when the sporadic-*E* season is waning, so activity is not as high as it would be earlier in the summer, but it is a fun contest and allows you to concentrate on a band where you need the grids.

ARRL June VHF Contest. Starts: 1800 UTC Saturday June 8, 2013; Ends: 0300 UTC Monday June 10, 2013. Rules: <http://www.arrl.org/june-vhf>.

The ARRL June VHF contest is usually the biggest contest of the summer season. Occurring near the height of sporadic-*E* season, there is usually lots of activity. With the summer weather grids are activated that are not usually seen on the band; portable stations are set up in remote grids and rovers journey to grids with few if any active VHF hams. The contest is for everyone, and a bit of a free-for-all, with operation on all bands from 6 meters to light allowed. You can stay plenty busy working stations on 6 during sporadic-*E* openings, squeezing out as many far-off grids as troposcatter conditions will support on 2 meters, and then moving those stations up the bands for more QSO points. You can even get in a bit of moonbounce and meteor scatter in the early morning hours if you are so equipped.

SMIRK. Starts: 0000Z Saturday June 15, 2013; Ends: 2400Z Sunday June 16, 2013. Rules: <http://www.smirk.org/contest.html>.

Sponsored by the 6 Meter International Radio Klub, the SMIRK summer contest is usually a low-key affair with the emphasis more on fun than competition. Contacts with club members counts more than contacts with non-club members, but membership in SMIRK is not required to participate. During band openings, this can be a fun and hectic contest. With the participation on 6 meters only, one does not need to have the higher bands to have a good showing. It is pure 6 meters.

ARRL August UHF. Starts: 1800 UTC Saturday August 3 , 2013; Ends: 1800 UTC Sunday August 4, 2013. Rules: <http://www.arrl.org/august-uhf>.

This is a specific contest for the bands 222 MHz and up. During most of the year, activity can be sparse on the UHF and microwave bands, so a weekend of concentrated activity can fill in those band grids you need for VUCC. One can concentrate on the higher bands without having to worry about missing an opening on 6 or 2. Rovers tend to be louder on these bands as antennas have higher gains for the same bandwidth and the noise is lower. Participation is usually modest for this contest, so you won't be inundated with QSOs, but it is an important event for the UHF and microwave community, so get on and show your support for fellow UHF and microwave operators. If you want to try UHF and microwave operation, but have been discouraged by the lack of activity, this is a good place to start.

Logging

Submission of a log is important, even if you don't think you won anything. It shows support to the contest sponsor and it lets other operators in the area know that you are interested in VHF and UHF operation. Electronic log submissions are encouraged in Cabrillo format. If you just log on paper, that is OK, too. Paper logs can be converted to Cabrillo format on a web log site: <http://www.b4h.net/cabforms/>.

This can be tedious for long logs. Several computer-based loggers are available that will handle the VHF contests. I use N1MM or RoverLog for VHF contesting, but there are other loggers available.

CW

Although much of the contest activity is on phone, CW plays an important role in contesting. With the advent of high-performance HF rigs that include 6 meters, more HF contesters, proficient in CW are using CW in VHF contests. If you have trouble raising someone on phone, try CW; it has a 10 dB or so advantage. Look in the CW section of the band for early activity in a band opening. If you don't know CW, learning it requires some dedication, but the rewards pay off big above in the VHF bands.

Calling Frequency

Use, but don't abuse, the calling frequency. When the band is open and there

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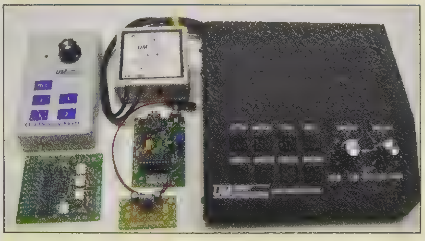

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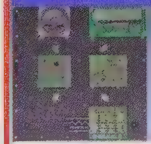

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are a lot of contacts to be made, there is no reason to be on the calling frequency. A short call to announce your presence on another frequency is sufficient. When you don't hear any activity, it is OK to use the calling frequency to initiate and make contacts, but don't monopolize it. There may be activity on that you can't hear, but that can hear you. Take frequent breaks to listen and let others use the frequency. The calling frequency is a shared resources. Use it wisely.

Antennas

Late spring and early summer are good times to improve your VHF and UHF antennas. Much of the success of VHF/UHF operating directly depends on effective radiated power (ERP), and the easiest way to improve your effective radiated power is to increase your antena gain or your antenna height. If you, like many newcomers to the VHF bands started with an omnidirectional loop, think about replacing it with a small Yagi. The difference will be impressive, particularly on troposcatter. As an example, going from a loop on 2m to a small 6-element Yagi 6 feet long will increase your capability immensely, likely adding another 100 miles or so to your capability. In many cases this will add several new grids to your circle of influence. The WA5VJB Yagis are a good place to start; it is hard to beat their bang for buck, and they are inexpensive and easy to build.

While you are improving your antenna think about replacing the feed line with one that has lower loss, particularly if you are using RG8X or equivalent above 6 meters, or RG8 above 222 MHz. There is a dB or two to be gained there, which often makes the difference between hearing someone near the noise level and missing them.

Increasing the height of your antenna will help a lot as well. Even a small height increase of 10 feet can be important, particularly if your antenna is low to begin with. Getting the antenna away from noise sources, above the trees and away from your house or garage all help.

Summer is the ideal time to do these improvements. You will regret it next winter if you don't.

F-Layer Propagation

It is looking less and less like we will be getting *F*-layer propagation this solar cycle. The sun has fairly low activity this cycle and it appears that it will not produce enough energy to ionize the *F*-layer sufficiently to support a maximum usable frequency (MUF) at 6 meters and above. Still the solar output is difficult to accurately predict, and short-term solar output may be enough to support *F*-layer propagation for short periods of time. Look for *F*-layer propagation when the sunspot number is above 150 (it is now about 75) particularly if it has been that high for several days, or when there has been a significant solar flare. But don't hold your breath for worldwide propagation on 6 meters this solar cycle. It doesn't look like it is going to happen.

Questions?

If you have questions on any aspect of VHF/UHF operation, or want to see a particular topic covered in this column, let me know. I will be happy to address topics of interest. Just ask.

73, James, KK6MC

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By Tomas Hood,* NW7US

VHF PROPAGATION

The Science of Predicting VHF-and-Above Radio Conditions

Some Basic Propagation and Space Weather Terms

In the last edition of this column, we explored the ionosphere and how radio waves may be propagated long distances by way of refraction in the various layers that make up this high-altitude layer of our atmosphere. Now let's explore some basic terms and concepts involving space weather and radio-wave propagation.

Sunspots

Sunspots are magnetic regions on the Sun with magnetic field strengths thousands of times stronger than the Earth's magnetic field. Plasma flows in these magnetic field lines of the Sun. Sunspots appear as dark spots on the surface of the Sun. Temperatures in the dark centers of sunspots (the "umbra") drop to about 3700 K, compared to 5700 K for the surrounding photosphere. This difference in temperatures makes the spots appear darker than elsewhere. Sunspots typically last for several days, although very large ones may live for several weeks. They are seen to rotate around the Sun, since they are on the surface, and the Sun rotates fully every 27.5 days.

Sunspots usually form in groups containing two sets of spots. One set will have a positive, or north, magnetic field while the other set will have a negative, or south, magnetic field. The magnetic field is strongest in the darker parts of the sunspot. The field is weaker and more horizontal in the lighter part (the "penumbra").

Since the time of Galilea Galileo, who made the first European observations of sunspots in 1610, observers and scientists have discovered a great deal about the Sun and its influence on the Earth and our atmosphere. The Chinese and many other early civilizations were the first to discover sunspots. Daily sunspot observations were started at the Zurich Observatory in 1749. By 1849, continuous sunspot observations were recorded. Over time, cycles in solar activity were revealed. The sunspot activity has a cycle that lasts for an approximate eleven-year period. The cycle starts with very quiet solar activity with very few sunspots, then peaks about three to five years later with a very high number of daily sunspots, and then decreases in sunspot activity until the end of the solar cycle.

In 1848, the Swiss astronomer Johann Rudolph Wolf introduced a daily measurement of sunspot number. His method, which is still used today, counts the total number of spots visible on the face of the Sun and the number of groups into which they cluster, because neither quantity alone satisfactorily measures sunspot activity.

The sunspot number is calculated by first counting the number of sunspot groups and then the number of individual sunspots. The "sunspot number" is then given by the sum of the number of individual sunspots and ten times the number of groups. Since most sunspot groups have, on average, about ten spots, this formula for counting sunspots gives reliable numbers even when the observing conditions are less than ideal and small spots are hard to see.

Because one observer may have difficulty in accurately counting the day's sunspot number (it might be a cloudy day, after all), observations are made at various locations around the world. In addi-

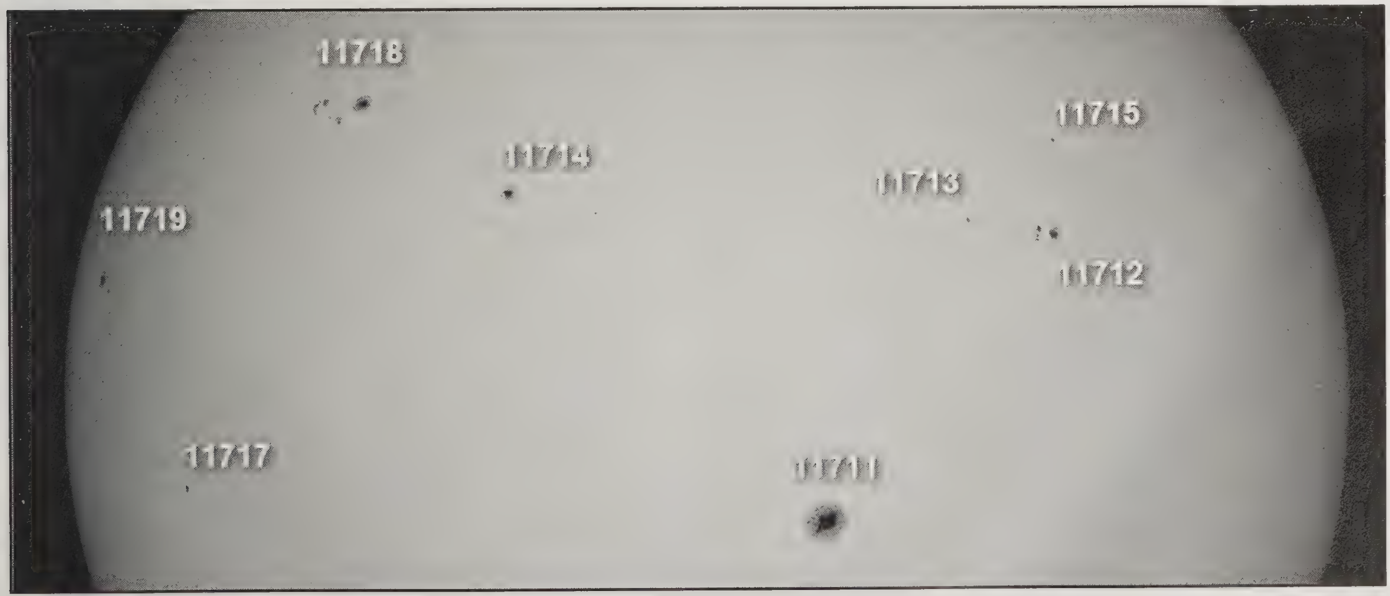

Figure 1. In this "intensitygram" (IGR) captured in "white light" (visible to our eyes) by the Solar Dynamics Observatory on April 6, 2013, a number of sunspot regions may be seen. Sunspots are an indication of solar activity and are directly related to the propagation of radio waves. (Credit: SDO/HMI

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tion, images are taken by spacecraft far above our atmosphere.

To compensate for the many limitations of observing the Sun at various places, each daily international number is computed as a weighted average of measurements made from a network of cooperating observatories.

Smoothed Sunspot Number

The daily sunspot number has little, if any, relationship to ionospheric variability. However, the most widely used Ionospheric Index, R12, is derived from the daily sunspot numbers. The R12 index is a 12-month smoothed relative sunspot number. This 12-month smoothed sunspot number (SSN) is derived by using the calculation based on the Lincoln-McNish smoothing function:

$$[(n1/2)+(n2+n3+...n11+n12)+(n13/2)]/12$$

where:

n1 = 1st Month/Year in Series,
n7 = 7th Month/Year in Series, and
n13 = 13th Month/Year in Series

For example, to calculate the R12 index for July 2005, add half of the January 2005 value plus the sum of the February through December 2005 values plus half of the January 2006 value and by divide the sum by 12.

In general terms, the smoothed sunspot numbers give us a way to measure the Sun's overall activity; the more active the Sun is, the higher the sunspot count. Scientists have discovered a direct correlation between the Sun's sunspot activity and our ionosphere activity. The more sunspots observed, the greater the ultraviolet energy bombarding the Earth. Since the ionosphere is formed by the ultraviolet energy from the Sun, the more sunspots on the Sun, the more energized the ionosphere becomes.

The 10.7-cm Radio Flux

Another measurement of solar activity, of course, is the 10.7-cm radio flux. This measurement is useful to the radio amateur because it provides a somewhat accurate way to assess how much energy the Sun is radiating. Since long-range DX depends on the ionospheric refraction of our shortwave radio signals and since the ionosphere depends on solar energy for its existence, the more solar energy available, the better the DX.

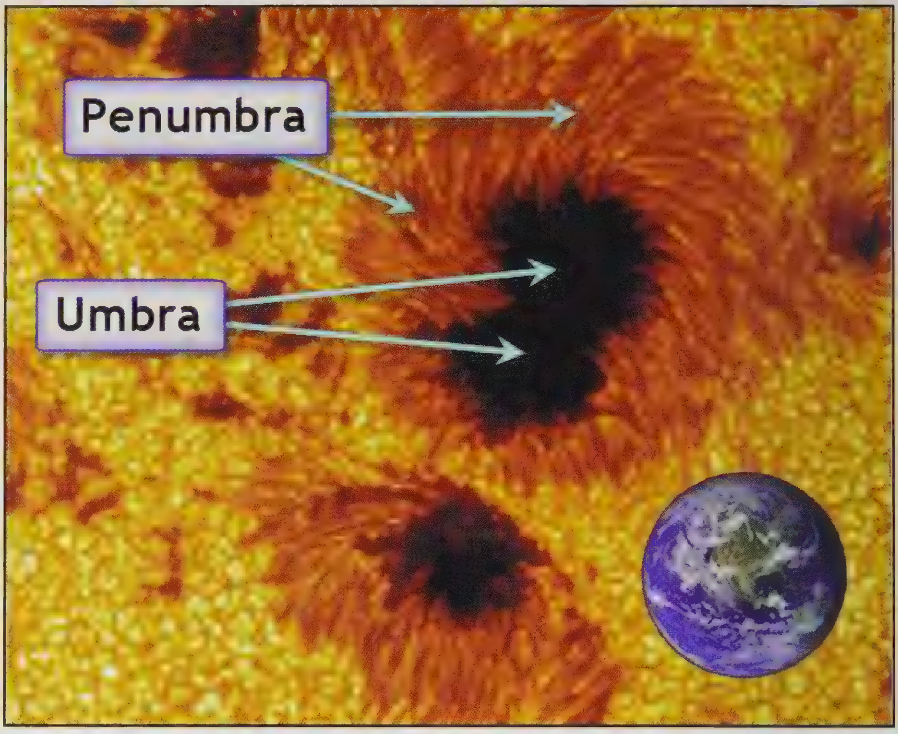

Figure 2. Sunspot, showing the darker (cooler) center, the "umbra," and the outer "penumbra." Notice the size of these sunspotin comparison with the Earth (the Earth is artifically superimposed on this image). (Source: NASA)

Scientists have routinely been measuring the flux of microwaves from the Sun at wavelengths between 3 and 30 cm (frequencies between 10 and 1 GHz) since 1947. These solar radio emissions come from high in the chromosphere and low in the corona. Specifically, the radio flux has two different sources: thermal bremsstrahlung (see: http://g.nw7us.us/JGG142) due to electrons radiating when changing direction by being deflected by other charged particles; and "gyro"-radiation (http://g.nw7us.us/JGGpQ5) due to electrons radiating when changing direction by gyrating around magnetic field lines. These mechanisms give rise to enhanced radiation when the temperature, density, and magnetic field are enhanced. This is why this microwave radiation is a good "measure" of "general" solar activity.

Strong solar magnetic fields are located in specific regions (often in active sunspot regions) that can live for weeks. These active regions often re-occur at or near the same location on the solar disc for months, perhaps even years. At solar cycle minimum, especially a "deep" one as we just witnessed between Cycle 23 and current Cycle 24, the effect of active regions largely disappears and we observe a sort of solar "ground state."

As the radio flux measurements (as contrasted with the sunspot count numbers) are unaffected by changes of human observers and their observing techniques and instrumental and atmospheric differences, these radio flux measurements may be a "truer" and more objective measure of solar activity.

The longest running series of solar observations is that of the 10.7-cm (or, 2800 MHz) radio flux (often simply referred to as F10.7), which was started by Covington in Ottawa, Canada in April 1947. These numbers are maintained at the Penticton site in British Columbia (http://g.nw7us.us/IbUc01). There are three measurements per day with small systematic differences. For daily records and analysis of propagation, we only use the noon value for Penticton at 2000 UTC, and we've used this noon value since 1991.

The late Robert Brown, PhD, (NM7M), proposed an even more accurate way to assess the level of energy available for ionization of the ionosphere on a given day (see his great introduction to radio signal propagation here: <http://g.nw7us.us/Itbyn0>). He explained that the hard X-ray energy present from the wavelengths of 1 to 8 Ångströms (*Å*, see <http://g.nw7us.us/JGFDCA>) provided the most effective ionizing energy throughout all of the ionospheric layers in our atmosphere.

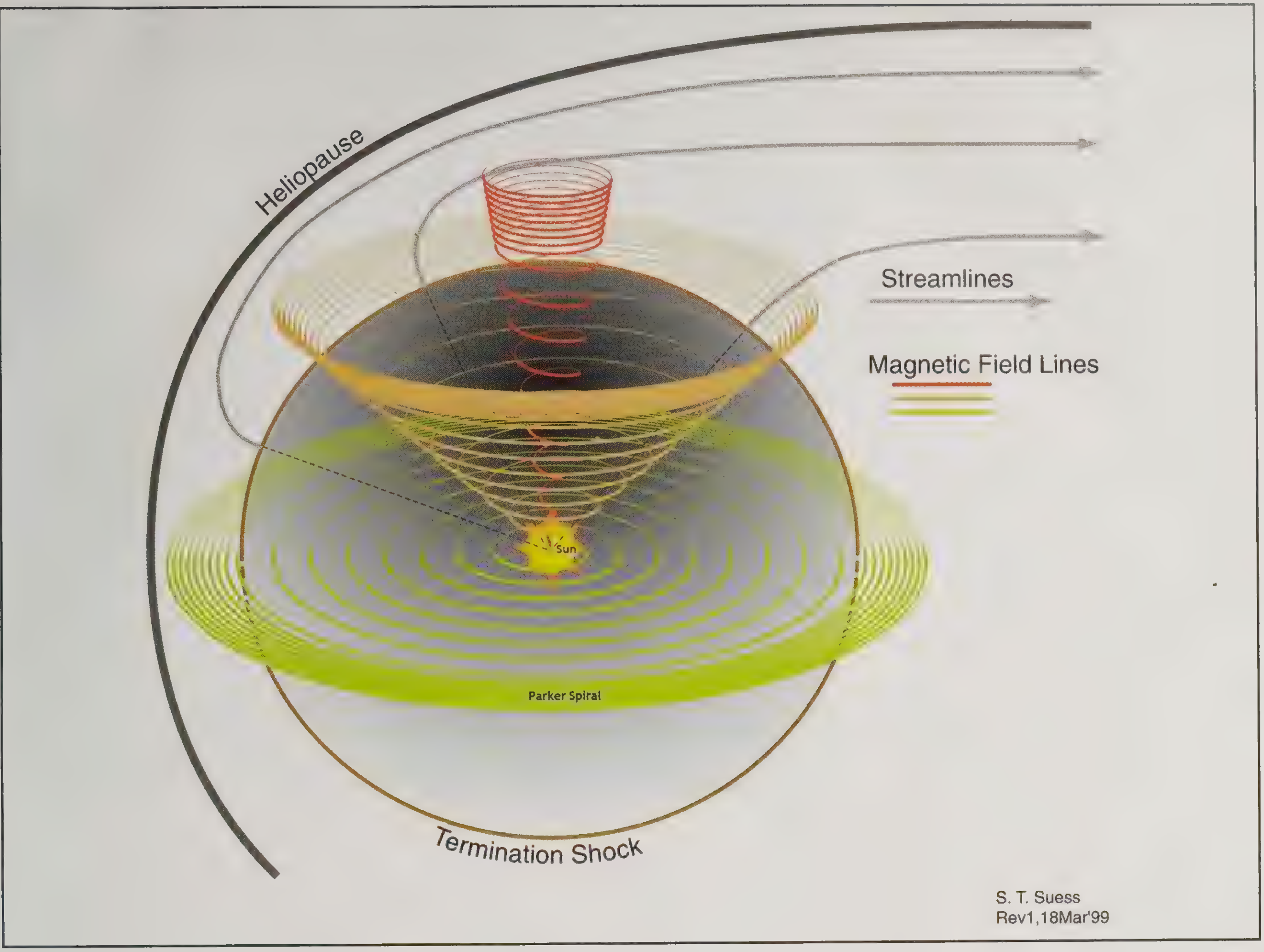

Figure 3. The magnetic field of the Sun is carried outward by the solar wind. Because the Sun rotates, the field is drawn into Archimedian spirals. These spirals are shown here, for three magnetic field lines at solar latitudes of 6, 45, and 84 degrees north (green, orange, and red, respectively). As the Earth orbits the Sun, it "wades" through the Parker Spiral and is always exposed to the solar wind. Coronal mass ejections ride the solar wind and if the CME is Earth-directed, the CME will collide with the Earth's magnetosphere, possibly triggering geomagnetic storms (see text). (Source: Steve Suess, NASA/MSFC)

The GEOS satellites measure these wavelengths and the resulting measurements are reported as the "background X-ray level" throughout the day. A daily average is reported, as well.

Just like X-ray flares, the background hard X-ray level is measured in watts per square meter (W/m^2), reported using the categories, A, B, C, M, and X. These letters are multipliers; each class has a peak flux ten times greater than the preceding one. Within a class there is a linear scale from 1 to 9.

Dr. Brown recorded the daily background X-ray levels for several sunspot cycles, and discovered that during solar cycle minimum periods the background X-ray levels remained at the A-class level. During the rise and fall of a solar cycle, the background X-ray energy levels remained mostly in the B range. During peak solar cycle periods, the background energy reached the C and sometimes even M levels.

The Solar Wind

The Sun, and each planet, has a magnetic structure. The Earth has a north pole and a south pole. Magnetic field lines run from pole to pole, forming a donut shape of magnetic flux energy. The Sun has a magnetic structure, as well. It can become quite complex, with several intertwined poles. The Sun even reverses its northern and southern poles each solar cycle.

The Sun's magnetic field permeates the entire solar system, and beyond. This region that stretches from the Sun outward past the end of the solar system is called the *heliosphere*. The magnetic field that originates in the Sun and stretches out through the heliosphere is called the *Interplanetary Magnetic Field* (IMF). The IMF interacts with the Earth and is a primary cause of space weather.

The IMF sprawls out away from the Sun in the form of a huge "current sheet," a vast expanding surface where complex magnetic field lines run from one solar pole far out into the solar system, arching back again along this sheet to return to the Sun's other pole.

We have spacecraft that measure the IMF near the Earth; one measurement is known as the "B sub-Z" (B_Z) which provides a way to observe the polarity at the spacecraft. The IMF magnetic field lines have polarities that change from north (seen as a positive B_Z) to south (indicated by a negative B_Z).

The huge solar current sheet that expands away from the Sun is 10,000 km thick and extends past the orbit of Pluto. The entire heliosphere is organized around this giant sheet, which carries an electrical current that is about sixteen orders of magnitude less than that of the current carried in an ordinary light bulb.

Ordinarily, the current sheet circles the Sun's equator, spreading out in a wavy sheet that might resemble a dancer's skirt that flies up while the dancer is spinning around. As Earth orbits the Sun, it dips in and out of the main structure of this wavy current sheet. On one side of this sheet, the Sun's magnetic field lines point northward. On the other side they point southward.

Space is not a vacuum, at least in our solar system. The Sun's atmosphere actually extends very far out from the Sun. Space in our system is filled with plasma, a low-density gas in which the individual atoms are charged. The temperature of the Sun's atmosphere is so high that the Sun's gravity cannot hold on to it. The plasma streams off of the Sun in all directions at speeds of about 300 to 400 kilometers per second (about 1 million miles per hour). This is known as the "solar wind."

The speed of the solar wind fluctuates, and sometimes the wind carries with it magnetically-complex plasma clouds. These clouds are regions where high-speed wind catches up with slow-speed wind, resulting in a twisting of the IMF's magnetic signature.

South-pointing solar magnetic field flux lines tend to connect with Earth's own magnetic field (think of holding two bar magnets together, one bar magnet's northern pole against the other bar's southern pole). Solar wind energy can then penetrate the local space around our planet and fuel geomagnetic storms.

Coronal Holes

At times, weak magnetic regions emerge on the Sun. Because of the weak magnetic structure and the resulting low density in these regions, solar plasma tends to "pour out" of these regions, billowing away from the Sun on the solar wind. These regions are known as "coronal holes" because of the way solar plasma escapes the Sun's gravitational and magnetic hold.

The corona is so hot that the gases in it lose some of their electrons in the powerful collisions between atoms. This creates "electrified gas," or "plasma." The solar plasma is a mixture of positively charged ions and negatively charged electrons.

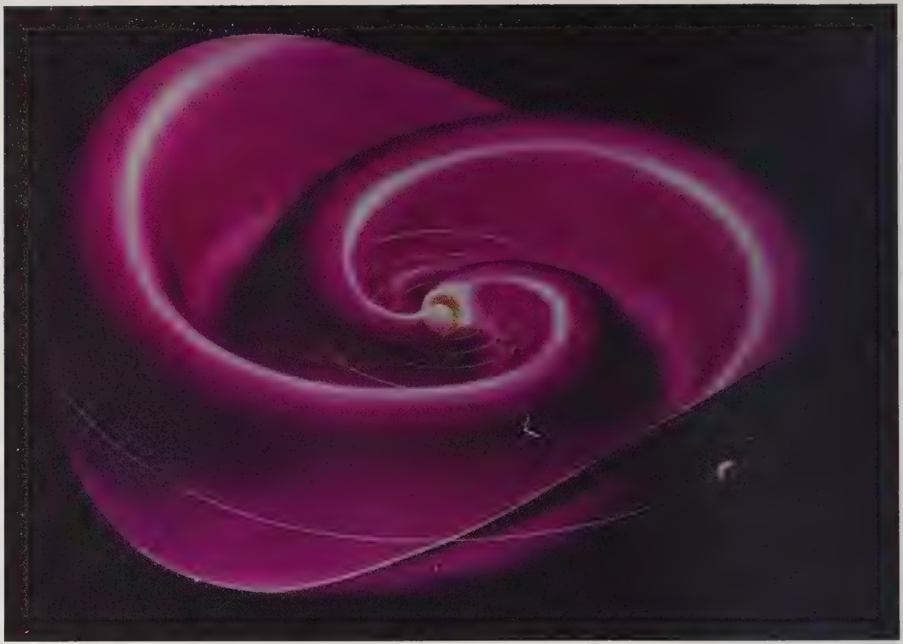

Figure 4. As the Sun rotates, its magnetic field twists into a Parker spiral, a form of an Archimedean spiral, named after its discovery by Eugene Parker. As the spiraling magnetic sheet changes polarity, it warps into a wavy spiral shape that has been likened to a ballerina's skirt. The cause of the ballerina spiral shape has sometimes been called the "garden sprinkler effect" and likening to holding a lawn sprinkler and moving it in your hand vertically up and down while your body rotates. The stream of water represents the solar wind and moves radially outwards at all times. The Earth is always moving through the Parker Spiral, exposed to the solar wind and the Interplanetary Magnetic Field (IMF). When the IMF is oriented "southward," it "reconnects" with the Earth's magnetic field, and a sort of window opens in our atmosphere through which solar plasma riding on the solar wind (such as coronal mass ejecta) enters, then follows the Earth's magnetic field lines down to the North and South Poles, triggering geomagnetic disturbances and storms, and possibly aurora. (Source: NASA)

An example of plasma can be seen by looking at a neon light. You are looking at plasma; gas inside the tube is energized to the point where light is emitted. Because plasmas are electrically conductive, they can steer magnetic fields. And they are steered by magnetic fields. Over coronal holes, solar magnetic fields are stretched and dragged into interplanetary space by the inertia of the expanding plasma that spirals out on the solar wind.

The speed of the solar wind is high (on average 600 to 800 km/s) over coronal holes and low (roughly 300 km/s) over the rest of the Sun. Plasma streams that have escaped from coronal holes ride the solar wind at much greater speed than the "quiet" solar wind.

Coronal holes follow the rotation of the Sun, taking about twenty-seven days for a full revolution around the Sun. This means that if the coronal hole lasts long enough, we'll see its influence on space weather every 27 days. When a coronal hole survives to make it around a second time, the coronal hole is said to be "recurrent." Coronal holes, then, are typically long-duration features.

Coronal holes are largest and most stable at or near the solar poles, and are a source of high-speed solar wind. However, those coronal holes situated at or near the solar equator tend to have the greatest impact on the Earth.

The Earth has a magnetic field with a north and a south pole that is enclosed within a region surrounding the Earth called the "magnetosphere." As the Earth rotates, its hot core generates strong electric currents that produce the magnetic field, which reaches 36,000 miles into space. The magnetosphere prevents most of the particles from the Sun, carried by solar wind, from impacting the Earth. The solar wind distorts the shape of the magnetosphere by compressing it at the front and causing a long tail to form on the side away from the Sun. This long tail is called the "magnetotail."

Geomagnetic disturbances are gener-

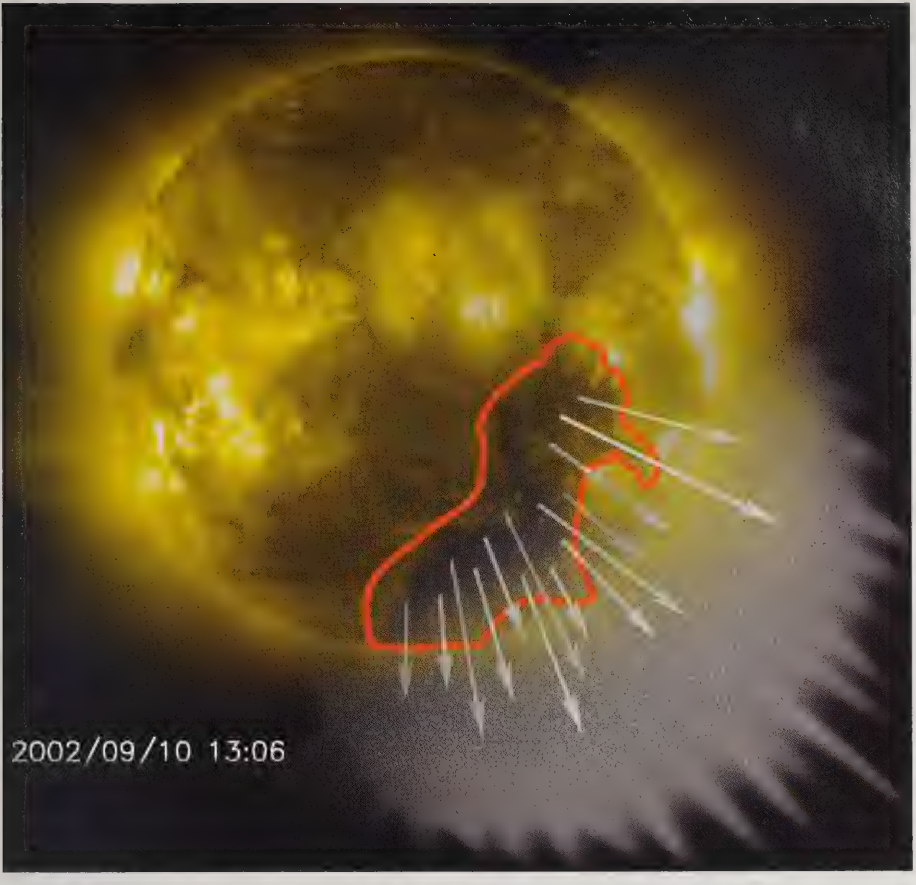

Figure 5. Coronal holes appear as dark areas of the corona when viewed in ultraviolet light. This large hole area seen here on September 10, 2002 had a direct impact on Earth. Coronal holes are often the source of strong solar wind gusts that carry solar particles into space. This one spewed a large stream of charged particles out to our magnetosphere and beyond. Solar wind streams take two to three days to travel from the Sun to Earth, so it probably originated from the Sun about 9 September. The magnetic field lines in a coronal hole extend out into the solar wind rather than coming back down to the Sun's surface as they do in other parts of the Sun. Although they are usually located near the poles of the Sun, coronal holes can occur other places as well (see text). (Source: NASA/SOHO)

ated by the encounter with southward-oriented magnetic fields of the IMF and solar wind, and the density and speed of the solar wind. The ability of the solar wind to disturb the Earth's magnetosphere is a function of its speed and the strength and orientation of the magnetic fields. In the presence of a strong southward magnetic field component (seen as a B_z with a negative index), a "connection" is made between the solar wind's magnetic fields and the Earth's magnetic fields (picture two pole magnets, where the North Pole of one "connects" with the South Pole of the other).

If the coronal hole is positioned along the Sun's equator, and is facing Earth, the plasma and solar particles from the coronal hole will pass by the Earth as the Sun rotates. The enhanced solar wind, dense with the extra solar plasma and with the speed elevations and variations caused by the coronal hole, buffet the Earth. If the magnetic orientation of the solar wind is southward, the coronal-hole-enhanced solar wind causes geomagnetic storms (some with aurora), and degrades ionospheric propagation faaaor days at a time. Because the coronal hole may last long enough to rotate back into Earth-directed position 27 days later, these stormy conditions will re-occur, too.

Geomagnetic activity is measured around the world, and is reported by the "*K*-index." These worldwide measurements are averaged and combined into the "Planetary *K*-index" (*Kp*), which is calculated and reported every three hours. These are then used to calculate the day's "Planetary *A*-index" (*Ap*). The higher these indices, the greater the geomagnetic disturbance. The *Kp* ranges from 0 (no activity; all quiet) to 9 (major storm level). If the *Kp* rises above 4, it is typical to see aurora; the greater the *Kp*, the stronger the possible resulting aurora. Of course, the stronger the geomagnetic storm, the more radio propagation on the high frequencies is degraded.

The ionosphere is affected by these changes due to the disturbance created by the solar wind. Because the Earth's magnetic field becomes disturbed, with quickly moving and chaotic magnetic field lines, the ionosphere experiences a decrease or even a depletion of ionization. Depressions in ionospheric density cause major communications problems because radio frequencies that previously had been refracting off the ionosphere now punch through. The Maximum Usable Frequency (MUF) on a given radio signal's path can be decreased by a factor of 2 during an ionospheric storm event (a substorm). Storm effects are more pronounced at high latitudes.

During the beginning phase of a solar cycle (we're near the middle, or peak, phase of solar Cycle 24), we see far fewer coronal holes than during the decline phase of the cycle. At any time, though, geo-effective (Earth-facing) coronal holes are a source of frustration for those involved with shortwave radio communications. Coronal-hole activity often contributes to days of very poor propagation on the high frequencies (30 MHz and below). On the other hand, when these geomagnetic storms and aurora occur, VHF may come alive via exotic Aurora-mode propagation.

I've provided live updates of the various indices, as well as other space weather and radio propagation data, at my page, <http://SunSpotWatch.com/>. We'll explore more about these concepts and terms in future editions. What are your experiences with low-VHF DXing and space weather?

Spring 2013 VHF Propagation

The sporadic-*E* (*Es*) season should open up with full throttle by the first week of May this year. Perhaps the Sun will be energetic enough to add long-distance *F*-region DX openings for this season, as well. The season will last from May to well into August.

The *Es* season is known for the quick, sometimes very strong openings on 6 meters, between short distances (hundreds of miles). This is a mostly summer-

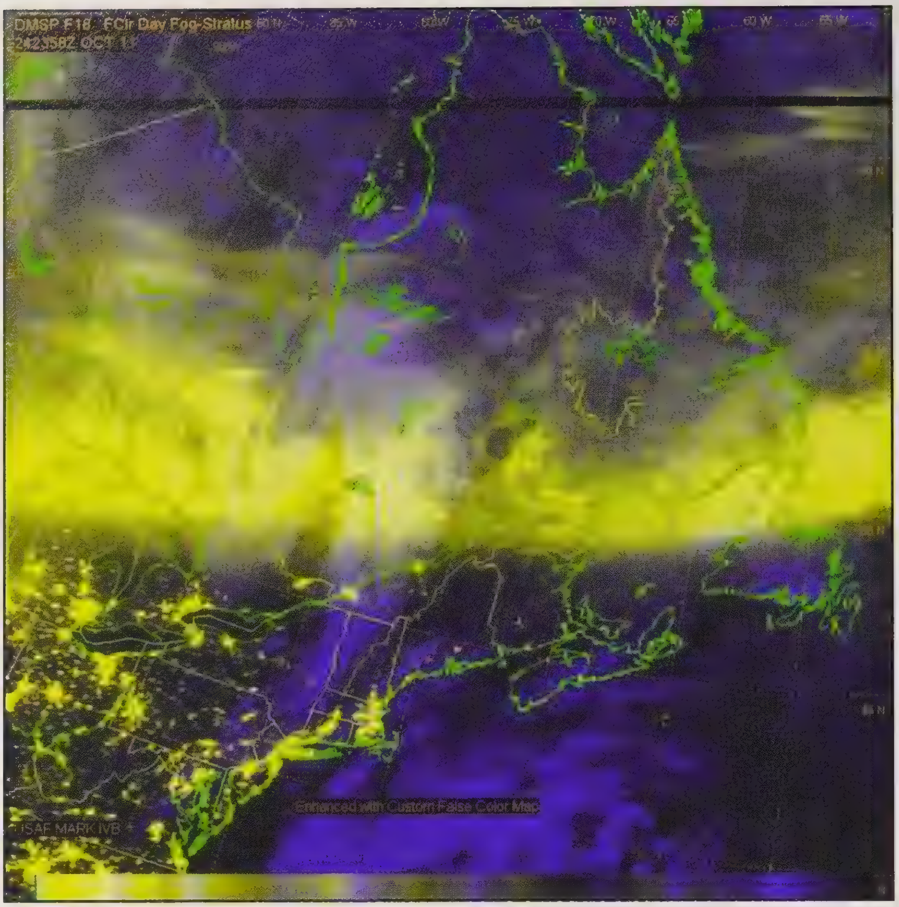
DMSP F18 FClr Day Fog-Stratus
60 W
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Figure 6. Nighttime visual and multispectral images of the Aurora Borealis over eastern Canada and the United States from the DMSP satellite F18 on October 25, 2011. This imagery was processed at Fleet Numerical Meteorology and Oceanography Center (FNMOC) in Monterey CA, USA and was taken by the weather satellite DMSP-F18. (Credit: Photo obtained from NASA Coupled Ion-Neutral Dynamics Investigation mission [Cindi in Space])

time mode of propagation where clouds of highly dense ionization develop in the *E* region of the ionosphere. These clouds might be very small, but regardless of their size, they seem to drift and move about, making the propagation off these clouds short and unpredictable. It is well documented that *Es* occurs most often in the summer, with a secondary peak in the winter. These peaks are centered very close to the solstices. The winter peak can be characterized as being five to eight times less than the summer *Es* peak.

Ten-meter operators have known *Es* propagation as the summertime "short skip." These "clouds" appear unpredictably, but they are most common over North America during the daylight hours of late spring and summer. *Es* events may last for just a few minutes to several hours, and usually provide an opening to a very small area of the country at any one time.

During periods of intense and widespread *Es* ionization, two-hop openings considerably beyond 1400 miles should be possible on 6 meters. Short-skip openings between about 1200 and 1400 miles may also be possible on 2 meters.

For a great introduction on mid-latitude sporadic-*E* propagation, visit the AM-FM DX Resource website <http://g.nw7us.us/10HEbUe>.

Tropospheric Ducting

Most propagation on VHF and above occurs in the troposphere. There are a number of well-documented modes of tropospheric propagation. The most common is line-of-sight propagation, which can, depending on the height of the transmitting and the receiving antennas, extend to about 25 miles. When you work simplex FM or FM repeaters in your local area, you are hearing typical line of sight tropospheric propagation.

Another possible mode of propagation is by tropospheric ducting. The term "tropospheric ducting" refers to the stratification of the air within the troposphere. These ducts are created by inversion layers formed from solar warming of the ground and the atmosphere immediately above it.

Under perfect conditions, the troposphere is characterized by a steady decrease in both temperature and pressure as height is increased. When layers form within this region of air, the refractive index between each layer causes a refraction of VHF and UHF radio waves. If the layers form in just the right way and at the right height, a natural wave-guide is created. A tropospheric duct develops. A VHF signal can be ducted hundreds, if not thousands, of miles. It is common for California stations to work Hawaii stations during tropospheric ducting between the islands and the Mainland.

It is worth watching for this mode of propagation. The spring weather season may well be violent and eventful this year. Advanced visual and infrared weather maps can be a real aid in detecting the undisturbed low clouds between the West Coast and Hawaii or farther during periods of intense subsidence-inversion band openings. This condition also occurs over the Atlantic. There is a great resource on the internet that provides a look into current conditions. Bill Hepburn has created forecast maps and presents them at <http://g.nw7us.us/MfedDD>, which includes maps for the Pacific, Atlantic, and other regions.

If you know that conditions are favorable for tropospheric ducting in your area, try tuning around the 162-MHz weather channels to see if you can hear stations way beyond your normal line-of-sight reception. It is possible to hear stations over 800 miles away. Amateur radio repeaters are another source of DX that you might hear from the other end of the duct.

These openings can last for several days, and signals will remain stable and strong for long periods during the opening. The duct may, however, move slowly, causing you to hear one signal well for a few hours, to then have it fade out and another station take its place from another area altogether.

The Solar Cycle Pulse

The (preliminary) observed sunspot numbers from January through March 2013 are 62.9, 38.0, and 57.9. The smoothed sunspot counts for July through September 2012 are 57.8, 58.2, and 58.1.

The monthly 10.7-cm (preliminary) numbers from January through March 2013 are 127.1, 104.4, and 111.2. The smoothed 10.7-cm radio flux numbers for July through September 2012 are 119.5, 119.2, and 118.9. The activity level is generally high enough to support 10-meter propagation, but rarely 6-meter propagation via the *F2*-region. If the cycle does gain increased activity, we'll see improvement on low-VHF propagation by way of the ionosphere.

The smoothed planetary *A*-index (*Ap*) numbers from July through September 2012 are 8.3, 8.1, and 7.8. The monthly readings from January through March 2013 are 4, 5, 9.

The monthly sunspot numbers forecast for May through July 2013 are 75, 78, and 81, while the monthly 10.7-cm flux forecast is 130, 133, and 134 for the same period. Give or take about eight points for all predictions. Notice that this is nearly the same level of activity that was forecast for the previous three months in this series.

(Also, note that these are preliminary figures. Solar scientists make minor adjustments after publishing, by careful review).

Feedback, Comments, Observations Solicited!

I am looking forward to hearing from you about your observations of VHF and UHF propagation. Please send your reports to me via e-mail, or drop me a letter about your VHF/UHF experiences (sporadic-*E*, meteor scatter?). I'll create summaries and share them with the readership. I look forward to hearing from you. You are welcome to also share your reports at my public forums at <http://forums.hfradio.org/>. Up-to-date space weather and radio propagation information is found at the NW7US Space Weather and Radio Resource Center, <http://sunspotwatch.com/>.

If you are using Twitter, follow @hfradiospacewx for space weather and propagation alerts, and follow me, @NW7US to hear from me about various topics including space weather and amateur radio news. Facebook members should check out the CQ VHF Magazine Fan Page at <http://www.facebook.com/CQVHF>, and the Space Weather and Radio Propagation Group at <http://www.facebook.com/spacewx.hfradio>.

Until the next issue, happy weak-signal DXing.

73 de Tomas, NW7US

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By Dr. H. Paul Shuch,* N6TX

DR. SETI'S STARSHIP

Searching For The Ultimate DX

How It All Began

"I was being asked to turn my back on something great—a job for life, backed by the taxing power of the state, with pension and full tenure, for a chance to tackle real fringe science with uncertain funding."

In previous columns, I've told the tale of how New Jersey industrialist Richard Factor, WA2IKL, founded the nonprofit SETI League, in the wake of Congress cancelling the short-lived NASA SETI program. But how exactly did I, a tenured full professor with a promising academic career, get roped into becoming its executive director? Well, campers, gather 'round the fire, and I'll tell you a little tale:

Richard was a ham friend. Since he didn't live nearby, he'd call me on the telephone, maybe once a year so we could catch up on our lives. Early one December, Richard rang me up. It was a call I'd long remember.

My wife had gone out Christmas shopping. I was home alone with lots of time to talk to my friend Richard on the phone.

"So, what's new with you?" he asked. He kept his questions short to give me lots of time to file as detailed a report as I was wont to give. This time I tried to make it clear that I had had a busy and most interesting year teaching some, and flying some, and getting on the air, not very often, but just to talk to here and there.

"And you?" I reciprocated. "Tell me, how's your life? Are you still a bachelor? Did you ever take a wife?"

"I may be deluded," Richard said, "but I'm no dunce. Marriage is the same mistake I never did make once." Richard then went on, of matters serious and petty, until he asked me, "Do you know what's going on with SETI?"

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RICHARD C FACTOR

The author, N6TX (left), and SETI League founder and president Richard Factor, WA2IKL, still run The SETI League together, and they talk on the telephone every December.

I was well aware that NASA's funding had been cut, and the search for life was in its final phases. However . . . maybe private funding would appear to save the day. "We can carry on," I said. There has to be a way. Richard, and I talked on for an hour and a half

This situation could make you cry, or maybe laugh.

It's no more a secret, so now I'm free to tell Richard's callsign—WA2IKL.

Then he dropped his bombshell, and at last I came to see this wasn't idle chitchat. He was interviewing me!

"I'm impressed there's so much about SETI that you know. I've founded a nonprofit. Would you like to run the show?"

I was being asked to turn my back on something great—a job for life, backed by the taxing power of the state, with pension and full tenure, for a chance to tackle real fringe science with uncertain funding. I began to feel there was just no way that I could pass up such a great deal! Therefore, I told Richard that his offer had a strange appeal.

I first took a sabbatical from teaching, just to find I liked the change. Thus, the next semester, I resigned. Those 20 years of teaching quickly slipped into the past.

Now for two decades I've run The SETI League. It's been a blast! The classroom was another life that I can scarcely remember, and all because my ham friend, Richard, called me that December.

73, Paul, N6TX

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*Executive Director Emeritus, The SETI League, Inc., <www.setileague.org>
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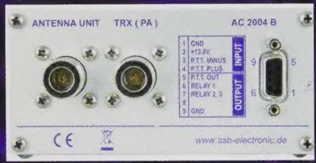
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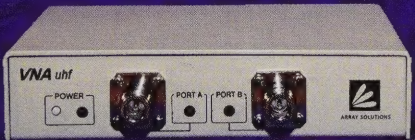
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ARRAY SOLUTIONS

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Array Solutions' products are in use at top DX and Contest stations worldwide as well as commercial and governmental installations. We provide RF solutions to the DoD, FEMA, Emcomm, UN, WFO, FAA and the State Dept. for products and installation of antennas systems, antenna selection, filtering, switching and grounding. We also offer RF engineering and PE consulting services.

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HF/50MHz TRANSCEIVER FT-950
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- Original YAESU IF DSP advanced design, provides comfortable and effective reception. IF SHIFT / IF WIDTH / CONTOUR / NOTCH / DNR
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COMPACT HF/50 MHz TRANSCEIVER WITH IF DSP

YAESU
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